Ministry of
Northern Development
and Mines
Ontario

Mines and
Minerals
Division

Precambrian Geology
Cassels and Riddell Townships

Ontario Geological Survey
Report 271

P. Born

1989

CANADA ONTARIO

This project is part of the five-year Canada-Ontario 1985 Mineral Development Agreement (COMDA), a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

90-03580/

© 1989 Queen's Printer for Ontario
Printed in Ontario, Canada

ISSN 0704-2582
ISBN 0-7729-6134-4

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Canadian Cataloguing in Publication Data

Born, P.

Precambrian geology of Cassels and Riddell townships

(Ontario Geological Survey Report, ISSN 0704-2582; 271)
ISBN 0-7729-6134-4

1. Geology--Ontario--Cassels. 2. Geology--Ontario--Riddell. I. Ontario. Mines and Minerals Division. II. Ontario Geological Survey. III. Title. IV. Series.

QE191.007 1989 557.13'147 C89-099661-X

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Parts of this publication may be quoted if credit is given. It is recommended that reference be made in the following form:

Born, P. 1989. Precambrian geology, Cassels and Riddell townships; Ontario Geological Survey, Report 271, 73p.

Scientific Editors: E.Garcia and T. Hoey

1000-89-Maracle

Foreword

Until 1986 the geological map coverage of Cassels and Riddell townships was at a reconnaissance level. The present detailed mapping project was designed to encourage mineral exploration interests and to provide assistance for mineral and land use evaluation.

The work reported here was funded under the five-year Canada-Ontario 1985 Mineral Development Agreement (COMDA) program.

The Precambrian bedrock of Cassels and Riddell townships hosts several polymetallic mineral deposits. The metallic commodities known to occur are copper, cobalt, silver, zinc, lead and minor gold. At the time this work was done there were no producing mines within Cassels and Riddell townships.

V.G. Milne

Director
Ontario Geological Survey

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GEOLOGICAL MAP

(back pocket)

Map 2526 – Precambrian geology, Cassels and Riddell townships, scale 1:20 000

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

***Note:** Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.*

Precambrian Geology Cassels and Riddell Townships

P. Born

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Manuscript approved for publication by A.C. Colvine, Chief Geologist. December 21, 1987. Report published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

This report describes the geology, stratigraphy, structure and mineral occurrences of Cassels and Riddell townships. The map area covers 190 km² in the District of Nipissing, approximately 5 km east of Temagami and 100 km north of North Bay.

Precambrian rocks of Archean and Proterozoic age underlie Cassels and Riddell townships. Most of the area is covered by a thin veneer of Cenozoic glacial deposits.

Archean rocks of the Superior Structural Province underlie the northwest, southwest and southeast margins of the area. These consist of mafic to felsic metavolcanic rocks of the younger volcanic complex (YVC) which locally consists of the Arsenic Lake, Link Lake and Upper formations. Metavolcanic rocks of the older volcanic complex (OVC) occur in the southwest part of Riddell Township. Mafic to intermediate metavolcanics in both sequences are made up of massive to pillowed, tholeiitic andesite flows. Intermediate to felsic metavolcanic rocks of the YVC are calc-alkalic and consist of minor flows and predominant pyroclastic rocks such as tuff, lapilli tuffs and lapillistone.

Felsic plutonic rocks are part of the Strathy batholith and consist mainly of granites which intrude the Archean metavolcanics and mafic intrusive rocks.

These rocks underwent moderate deformation, and greenschist metamorphism. Emplacement of northwest- and northeast-trending mafic dikes occurred mainly within the felsic plutonic terrane.

Folding along northeast-plunging axes resulted in the formation of the Lake Tetapaga syncline. Subsequent intense shearing accompanied by brittle and ductile failure occurred within the northeast-trending Link Lake deformation zone (LLDZ). It crosscuts the metavolcanic sequence of the Lake Tetapaga syncline in the Boot Bay area. Proterozoic rocks underlie most of the map area and consist of sediments of the Huronian Supergroup, Nipissing intrusive rocks and minor mafic dikes.

The local Huronian stratigraphy consists of the Gowganda and Lorrain formations of the Cobalt Group. Sediments of the Gowganda Formation are divided into a lower Coleman Member and an upper Firstbrook Member. Sedimentary rocks of the Coleman Member unconformably overlie the Archean basement, and consist of a basal breccia, matrix- and clast-supported conglomerates, pebbly wackes, mudstones and arkoses.

Sediments of the Firstbrook Member conformably overlie the Coleman Member. They typically consist of varieties of laminated mudstone, arenite, siltstones and wacke sequences. Ripple marks, cross-beds, loading structures and soft sediment deformation are common features.

Sediments of the Lorrain Formation consist mainly of arkoses and conformably overlie the Gowganda Formation in all areas except at one locality along the northern margin where a local angular unconformity was identified. Cross-bedding and graded bedding are common in the lower portions of the unit.

The Huronian sedimentary sequence was intruded by a major Nipissing diabase sill consisting of quartz diabase, lesser varied textured quartz diabase, and minor granophyre. Contact metamorphism resulted in local chloritization and epidotization of the rocks of the Gowganda and Lorrain formations at several localities.

The youngest Precambrian rock in the area is a northwest-trending olivine diabase dike of the Sudbury Swarm (1220 Ma) which cuts across Cassels Township. Deformation and lower greenschist metamorphism of the Huronian sequence occurred after the emplacement of the Nipissing diabase sill (2150 Ma) during the Penokean Orogeny some 1900 Ma. Folding has occurred about northeast-trending and subsequent northwest-trending fold axes. The second period of folding was possibly related to the Grenville Orogeny (approximately 1000 Ma) since its effects are mainly seen in the southern part of the map area which is closest to the Grenville Front.

Sporadic prospecting for silver and cobalt since 1904 has resulted in the discovery of numerous occurrences of copper, cobalt, silver, gold, zinc, lead and nickel in Cassels and Riddell townships. Polymetallic occurrences of these metals are either hosted within the margins of the Nipissing diabase; within sedimentary rocks of the Coleman Member adjacent to the sill; or within Archean felsic metavolcanics in the form of volcanogenic massive sulphides with minor copper and zinc mineralization. The geological environment is favourable for new discoveries of copper, cobalt and silver mineralization in close proximity to Nipissing diabase rocks; and copper, zinc and possibly gold mineralization hosted within Archean metavolcanic rocks which are part of the Lake Tetapaga syncline.

Résumé

Le présent rapport décrit la géologie, la stratigraphie, la structure et les gisements minéraux des cantons de Cassels et de Riddell. Le secteur cartographiée couvre 190 km² dans le district de Nipissing, à environ 5 km à l'est de Temagami et à 100 km au nord de North Bay.

Des roches archéennes et protérozoïques constituent le substratum des cantons de Cassels et de Riddell. La majeure partie du secteur est recouverte d'une mince couche de dépôts glaciaires cénozoïques.

Des roches archéennes de la province structurale Supérieure constituent le substratum des limites nord-ouest, sud-ouest et sud-est du secteur. Il s'agit de roches volcaniques métamorphisées mafiques et felsiques du Complexe Volcanique Récent (CVR) qui est formé localement par les formations du lac Arsenic, du lac Link et la formation Supérieure. Des roches volcaniques métamorphisées du Complexe Volcanique Ancien (CVA) affleurent dans la partie sud-ouest du canton de Riddell. Dans les deux séries, les roches volcaniques métamorphisées, de mafiques à intermédiaires, sont composées de coulées andésitiques tholéiitiques massives ou en coussins. Les roches volcaniques métamorphisées, d'intermédiaires à felsiques, du CVR sont calco-alcalines et se composent d'écoulements secondaires et surtout de roches pyroclastiques telles que de tuf, lapilli-tuf, et lapilli.

Les roches plutoniques felsiques font partie du batholithe de Strathy et sont principalement constituées de granites qui envahissent les roches volcaniques métamorphisées archéennes et les roches intrusives mafiques.

Ces roches ont subi une déformation modérée et un métamorphisme de type schiste vert. L'intrusion des dykes mafiques orientés nord-ouest, sud-est et nord-est, sud-ouest s'est surtout produite dans la formation géologique plutonique felsique.

Le plissement le long d'axes plongeants nord-est a abouti à la formation du synclinal du lac Tetapaga. Par la suite, un cisaillement intense accompagné d'une rupture déformante et cassante s'est produit dans la zone de déformation du lac Link d'orientation nord-est, sud-ouest intersectant la série de roches volcaniques métamorphisées du synclinal du lac Tetapaga dans la région de Boot Bay. Les roches protérozoïques constituent le substratum de la majeure partie du secteur cartographiée et sont composées de sédiments du supergroupe de l'Huronien, de roches intrusives de Nipissing et de quelques dykes mafiques.

Localement la stratigraphie huronienne se compose des formations du Gowganda et de Lorrain appartenant au groupe de Cobalt. Les sédiments de la formation du Gowganda se composent, à la base, du membre de Coleman et au sommet du membre de Firstbrook. Les roches sédimentaires du membre de Coleman recouvrent de façon discordante le socle archéen et se composent d'une brèche basale, de conglomérat à matrice prédominante et à clastes prédominants, de wackestones caillouteux, de mudstones et d'arkoses. La stratigraphie Huronienne locale se compose des formations du Gowganda et de Lorrain appartenant au groupe de Cobalt. Les sédiments de la formation du Gowganda se composent, à la base, du membre de Coleman et du membre de Firstbrook au sommet. Les roches sédimentaires du membre de Coleman recouvrent de façon discordante le socle archéen et se composent d'une brèche basale de conglomérats à matrice prédominante et à claste prédominants, de wakes, d'argilites et d'arkoses.

Les sédiments du membre de Firstbrook recouvrent de façon concordante le membre de Coleman. Il s'agit de séries de mudstones stratifiées, d'arénites, de siltstones et de wakes. Des ripple marks, des stratifications entrecroisées, des structures de charge et des déformations de sédiments meubles en sont des caractéres communs.

Les sédiments de la formation de Lorrain consistent principalement d'arkoses et recouvrent de façon concordante la formation du Gowganda dans tous les secteurs, sauf dans une localité le long de la limite nord-est où une discordance angulaire locale a été identifiée. Des stratifications entrecroisées, et des grano-

classement dans les strates se retrouvent communément dans les parties inférieures de l'unité.

La série sédimentaire huronienne a été envahie par un important filon-couche de la diabase de Nipissing composé d'une diabase de quartz, d'une diabase de quartz à textures moins variées et de quelques granophyre. Le métamorphisme de contact a provoqué la chloritisation et l'épidotisation locales des formations du Gowganda et de Lorrain dans plusieurs localités.

La roche précambrienne la plus récente du secteur est un dyke de diabase à olivine de l'essaim de Sudbury (1220 M.A.) qui traverse le canton de Cassels. La déformation et le métamorphisme de type schiste vert inférieur de la série huronienne se sont produits après l'intrusion du filon-couche de la diabase de Nipissing (2150 M.A.) pendant l'orogénèse pénokéenne (env. 1900 M.A.). Le plissement s'est produit le long des axes de plissement orientés nord-est, sud-ouest et plus tard nord-ouest, sud-est. La seconde période de plissement était peut-être reliée à l'orogénèse grenvillienne (env. 1000 M.A.) puisque ses effets s'observent surtout dans la partie sud du secteur cartographiée qui est le plus proche du front de Grenville.

Depuis 1904 la prospection sporadique d'argent et de cobalt a permis de découvrir de nombreux gisements de cuivre, de cobalt, d'argent, de zinc, de plomb et de nickel dans les cantons de Cassels et de Riddell. Des dépôts polymétallique de ces métaux se trouvent soit à la bordure de la diabase de Nipissing; soit dans les roches sédimentaires du membre de Coleman adjacentes au filon-couche; soit dans les roches volcaniques métamorphisées archéennes felsiques, sous forme de sulfures massifs d'origine volcanique avec une faible minéralisation en cuivre et en zinc. Le contexte géologique est propice à la découverte de nouveaux gisements de cuivre, de cobalt et d'argent à proximité de la diabase de Nipissing; et à la découverte de cuivre, de zinc et peut-être d'or dans les roches volcaniques métamorphisées archéennes qui font partie du synclinal du lac Tetapaga.

Precambrian geology, Cassels and Riddell townships, by P. Born; Ontario Geological Survey, Report 271, 73p. ISBN 0-7729-6134-4.

Introduction

Location and Access

The map area (190 km²) consists of Cassels and Riddell townships and is located 5 km east of Temagami in the District of Nipissing. It is bounded by latitudes 46°58′25″N and 47°08′00″N and longitudes 79°38′00″W and 79°45′20″W (Figure 1).

Road access to the area is limited to two gravel roads which lead from Highway 11 to Cassels Lake. One is in Cassels Township and provides access to Temagami, the other is Lowell Lake Road in Riddell Township. Road access to the northern part of Cassels Township is along a major power line, using four-wheel-drive vehicles. Several old gravel lumber roads east of Cassels Lake also provide walking access to the eastern part of the map area.

The Ontario Northland Railway cuts across the southwestern corner of Riddell Township and provides additional walking access.

Cassels, Rabbit, Pishabo and Net lakes provide water access to most other parts of the map area.

Previous Geological Work

Various parts of Cassels and Riddell townships were explored and described by Bell (1891), Coleman (1899), Miller (1901), Miller and Knight (1911) and Knight (1919). However, Barlow (1899) gave the first geological description of the area based on work carried out in a systematic manner. His work spanned the period 1887 to 1908 when the Geological Survey of Canada published the Nipissing and Timiskaming map sheets (17 900 km²) at a scale of 1 inch to four miles (1:253 440).

Early mineral prospecting dates back to the period 1904 to 1912 with silver and cobalt exploration in the area following the discovery of silver and cobalt in the nearby Cobalt and South Lorrain mining camps. Since that period mineral exploration has been sporadic. A detailed account of the history of mineral exploration is given in a later section on Economic Geology.

Other early geological work in the vicinity includes detailed mapping by A.G. Burrows (1909) in the South Lorrain Silver area east of Cassels and Riddell townships.

The first comprehensive geological mapping of the area was done by Todd (1925) on a reconnaissance scale (1:63 360) of one inch to one mile. The map area included Cassels and Riddell townships and the rest of the Matabitchuan area between Lake Temagami and Lake Timiskaming. Subsequent and more detailed mapping in areas adjacent to Cassels and Riddell townships were carried out by McIlwaine (1970), Bennett (1978), Symk and Owsiacki (1986) and Fyon and Crockett (1986). The regional Quaternary geology as mapped by Roed (1979) and Gartner (1980) is shown on Ontario Geological Survey maps 5024 and 5040, respectively. The regional geology map is Map 2362, Sudbury-Cobalt Sheet (Card and Lumbers 1977) and magnetic characteristics of the area are shown on Geological Survey of Canada (GSC) Aeromagnetic Series maps

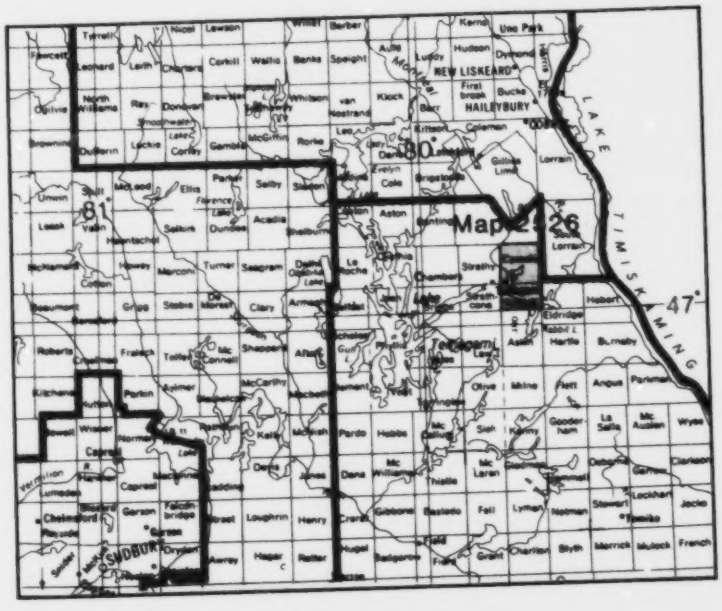

Figure 1. *Key map showing location of Cassels and Riddell townships.*

1490G-Ingall Lake (GSC 1965a) and 1491G-Temagami (GSC 1965b).

Acknowledgments

The author was ably assisted during the 1986 field season by senior assistants C. Stephenson and M. Hitch. Each of them mapped approximately one third of the area. E. Zwicker, A. Avlonitis and P. MacEachern were junior assistants. Some independent mapping was done by P. MacEachern (1987) as part of a BSc thesis studying the contact metamorphism of sedimentary rocks of the Lorrain Formation in the Sunrise Lake area.

All of the drafting, modal analyses, and cutting and staining of rocks was done by C. Stephenson while he was a geological assistant with the Precambrian Section of the Ontario Geological Survey (OGS) during the winter of 1986-1987.

During the field season, the field crew stayed at a cabin situated along the east shore of Cassels Lake. The author wishes to thank Jim and Sheila Richardson for the use of the cabin and other helpful assistance during the summer. Thanks are also due to Conrad Hamilton and the staff of the Ministry of Natural Resources in Temagami for the use of equipment and valuable information and help during the mapping project.

Topography and Drainage

Within the map area, the topography is typified by a series of low to moderately high hills and cliffs with average relief of 40 to 50 m. Elevations vary from a low of 300 m above sea level on Cassels Lake to a high of 410 m in an area northeast of Blueberry Lake.

Moderately well exposed bedrock occurs throughout most of the map area. A maximum of 25 percent exposure to the southwest of Pishabo Lake is in an area underlain by sediments of the Proterozoic Gowganda Formation and Archean metavolcanics. Outcrop exposures for the entire area averages about 15 percent.

Differences in bedrock lithologies and structures control local variations in topographic relief in the map area. For example, Proterozoic sediments of the Gowganda and Lorrain formations are generally exposed by linear cliffs, scarps and ridges with little exposure in valleys and plateaus between ridges. Archean lithologies, however, are exposed in a rolling terrain with more continuous bedrock in a series of low and flat outcrops. Approximately 10 percent of the area is covered by water. A chain of lakes consisting of Obashkong, Gosselin, Cassels, Snake Island and Rabbit lakes forms the largest single body of water. It extends from the northern to southern boundary of the map area. All were separate lakes prior to the construction of dams on Rabbit Lake and the Matabitchuan River. Other major lakes include Boulton, Twin, Sunrise, Blueberry, Pishabo, Monty, Leroy, Watson and Summit lakes. Bedrock exposures are generally good along the shores of all lakes. The few creeks that occur generally dry up during the summer season. They usually connect the inland lakes to Rabbit and Cassels lakes which in turn drain eastward into the Matabitchuan River system and Lake Timiskaming.

General Geology

Underlying Cassels and Riddell townships are Archean supracrustal and plutonic rocks, Early Proterozoic supracrustal and intrusive rocks, and Middle Proterozoic (Keweenawan) dike rocks. Cenozoic sediments compose the youngest rocks in the area and are represented by Pleistocene and Recent gravelly sand and organic debris.

A generalized summary of the rock types occurring within the area is given in Table 1.

Archean rocks are exposed in the northwest and southwest corners of the map area. Early Proterozoic rocks of the Huronian Supergroup and Nipissing intrusive rocks are exposed in all other areas. The youngest Precambrian rocks are represented by a northwest-trending, 200 m wide, olivine diabase dike of the Sudbury Swarm which cuts across Cassels Township (Figure 2).

ARCHEAN

METAVOLCANIC ROCKS

Introduction

Archean rocks underlie the northwestern part of the map area and consist of an 8 km long, northeast-trending metavolcanic belt intruded by Archean felsic and mafic plutonic rocks. This metavolcanic terrane is an eastward extension of the Temagami greenstone belt which has been subdivided into a younger volcanic complex (YVC) and older volcanic complex (OVC) by Fyon and Crockett (1986). Archean metavolcanic rocks in Cassels Township are part of the YVC and those in Riddell Township are part of the OVC.

The oldest rocks of the YVC in the Net Lake area (Cassels Township) are pillowed to massive mafic flows of the Arsenic Lake formation (Fyon and Crockett 1986). These are found along the northern limb of the Lake Tetapaga syncline. Overlying the Arsenic Lake formation are felsic pyroclastic rocks such as tuffs, lapilli tuffs, lapillistone with minor mafic to intermediate, and intermediate to felsic flows which correspond to the Link Lake formation. The youngest Archean volcanic rocks are pillowed to massive mafic flows of the Upper formation which occupy the core of the syncline. Clastic rocks of the Turtle Lake formation which normally overlie the Link Lake formation further to the west of the area, appear to be absent in Cassels Township.

Rocks of the OVC outcrop west of Lower Twin Lake in southwest Riddell Township and consist mainly of well-foliated, massive and pillowed mafic flows and minor pyroclastic rocks.

Mafic to Intermediate Metavolcanics

Mafic to intermediate metavolcanics (i.e., basalts and andesites) are recognized on the basis of colour, texture, hardness, specific gravity and lithostructures. Intermediate metavolcanics (andesites) are lighter coloured, more siliceous and characterized by colour indices of between 15 and 25 percent whereas mafic varieties (basalts) have colour indices of greater than 35 percent. The rocks are generally softer than a hardness of six and exhibit fine-grained, brownish-green-coloured weathered surfaces and dark to medium green fresh surfaces. In all areas, the rocks have undergone sufficient metamorphism, carbonatization and deformation to obliterate many of the original textures, mineralogy and structures.

Mafic to intermediate metavolcanic rocks constitute the predominant rock types of the OVC and that of the Arsenic Lake and Upper formations of the YVC in the map area. Rocks of andesitic composition are common within the YVC in the Outlet Bay area and the OVC in Riddell Township.

Massive, fine-grained mafic flows and lesser pillowed flows are the main rock types. Pillowed flows are best exposed in the Outlet Bay area of Cassels Township (YVC) and to the west of Lower Twin Lake (OVC) in Riddell Township. Pillows are generally well formed and preserved, and range in length from 0.2 m to 1 m and from 10 to 30 cm in width (Photo 1). Epidotized selvages, fine-grained interpillow hyaloclastite and well-developed pillow packing are several of the characteristics of pillowed mafic flows. Minor amygdules are also found within the centre of some of the pillows. Limited exposures of mafic flows did not permit the determination of the thickness of individual flows. Top directions were determined from pillow shapes and pillow packing geometry.

Flow breccia and minor pillow breccias are generally dark green and consist of angular mafic fragments of comminuted lava, and pillows, set in a finer-grained, mafic volcanic matrix (Photo 2). Locally, these rock types are most abundant within the OVC west of Lower Twin Lake in Riddell Township.

Porphyritic varieties of mafic volcanics are uncommon and consist of plagioclase-phyric, mafic metavolcanic flows. They have been observed as variolitic flows along the southern shore of Net Lake and are part of the Arsenic Lake formation of the YVC.

Rocks classified as amphibolites are rare and consist of either coarse-grained flows and/or recrystallized, medium-grained flows at the edge of the volcanic belt in Riddell Township.

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR CASSELS AND RIDDELL TOWNSHIPS.

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

Glacial, glaciofluvial, swamp, lake and stream deposits

UNCONFORMITY

PRECAMBRIAN

MIDDLE PROTEROZOIC

Olivine Diabase Dikes (Sudbury Swarm)

Coarse- and fine-grained olivine diabase

INTRUSIVE CONTACT

EARLY PROTEROZOIC

Mafic Intrusive Rocks

Nipissing Diabase

Quartz diabase, varied textured diabase, leucocratic quartz gabbro, granophyre, hydrothermally altered diabase

INTRUSIVE CONTACT

HURONIAN SUPERGROUP

COBALT GROUP

Lorrain Formation

Arkose, minor feldspathic lithwacke, micaceous, lithic arkose; micaceous, hematitized arkose; fine-grained micaceous arkose interbedded in coarse-grained lithic arkose; thin mudstone, siltstone interbeds in arkose; metamorphosed sediments

CONFORMABLE CONTACT (local angular unconformity)

GOWGANDA FORMATION

FIRSTBROOK MEMBER

Arenite, wacke, arkose, shaley mudstone, siltstone, claystone; tectonically brecciated and sheared sediments; metamorphosed sediments

CONFORMABLE CONTACT

COLEMAN MEMBER

Pebbly wacke, silty-pebbly wacke; arkose, pebbly arkose, pebbly arkosic wacke; arenite, pebbly arenite; mudstone, pebbly mudstone, siltstone and claystone; matrix-supported conglomerates; clast-supported conglomerates; basal breccia; metamorphosed sediments

UNCONFORMITY

ARCHEAN

MAFIC INTRUSIVE ROCKS

Diabase, gabbro, glomeroporphyritic diabase, lamprophyre

INTRUSIVE CONTACT

FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

(CHAMBERS-STRATHY BATHOLITH)

Biotite granite; biotite granodiorite and minor trondjhemite; quartz monzodiorite; contaminated border zone with numerous xenoliths; aplite and felsite dikes; chloritized, sheared and brecciated granitoid rocks

INTRUSIVE CONTACT

METAMORPHOSED MAFIC TO ULTRAMAFIC INTRUSIVE ROCKS

Pyroxenite, gabbro, leucogabbro

INTRUSIVE CONTACT

METAVOLCANIC ROCKS

Intermediate to Felsic Metavolcanic Rocks

Dacite, rhyodacite, rhyolite, tuff, lapilli tuff, flows, crystal tuff, lapillistone

Mafic to Intermediate Metavolcanic Rocks

Basaltic flows, andesite, pillowed flows, flow breccia, schists, amphibolite, variolitic basalts

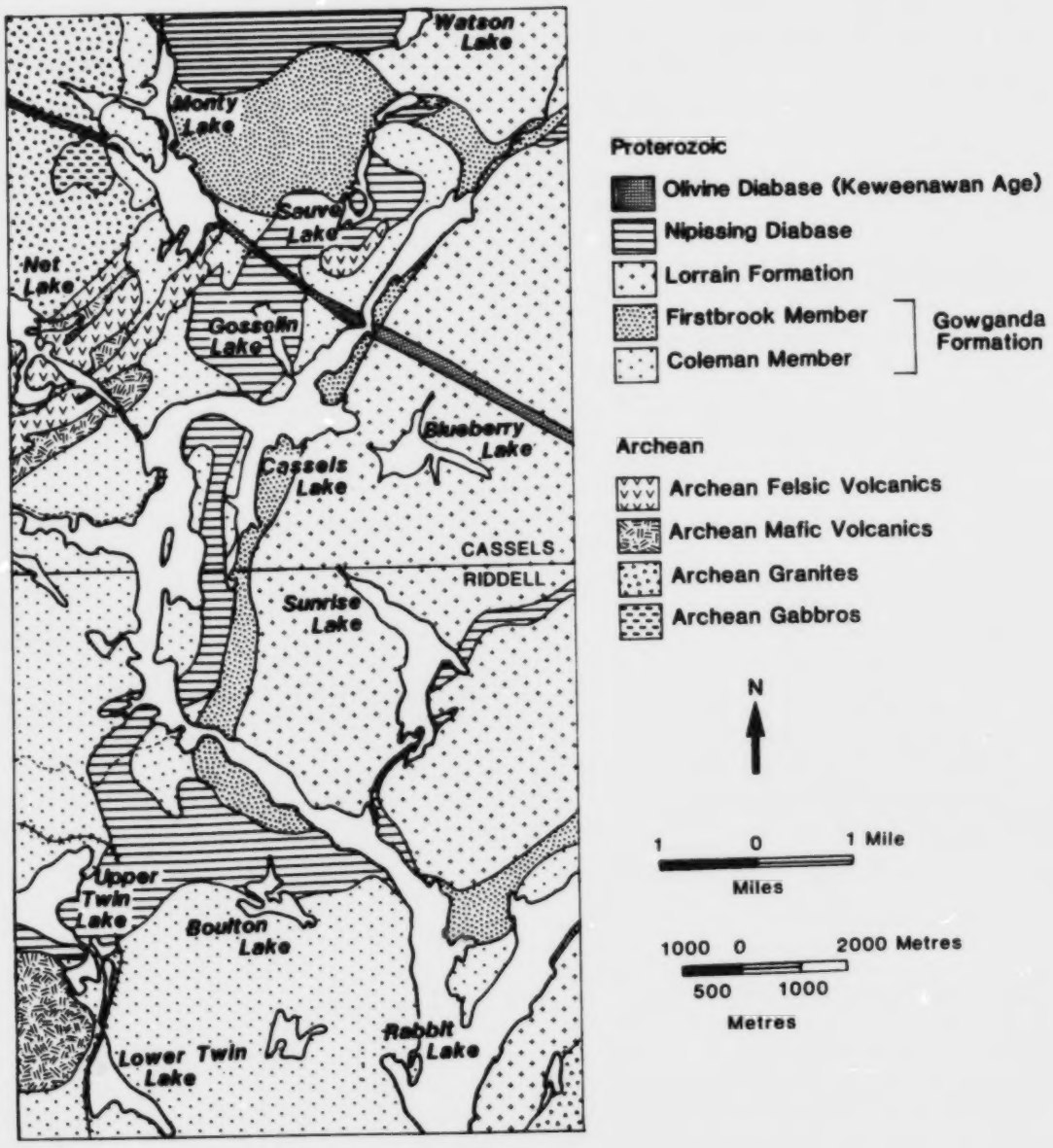

Figure 2. *General geology of Cassels and Riddell townships.*

Chlorite schists are minor, and based on their fine-grained homogeneous texture, probably represent sheared mafic volcanic flows rather than mafic pyroclastic rocks. Rocks of this type are located within a Nipissing diabase contact aureole near Sauvé Lake and within the northeast-trending LLDZ which has deformed much of the local metavolcanic sequence of the Lake Tetapaga syncline.

Thin section studies of eleven samples indicate that the mafic metavolcanic rocks consist mainly of greenschist with minor amphibolite and low-grade contact hornfels metamorphic mineral assemblages.

Amphibolite to upper greenschist facies rocks are located in the OVC in southwest Riddell Township. In hand specimen, the amphibolites are fine to medium grained, granoblastic and have dark green-coloured weathered and fresh surfaces. A total absence of carbonate and characteristic well-foliated megascopic features distinguish the rocks of the OVC in Riddell Township from rocks of the YVC in Cassels Township.

In thin section, the amphibolites and upper greenschist facies rocks exhibit a granoblastic texture with equant, blue-green hornblende, untwinned pla-

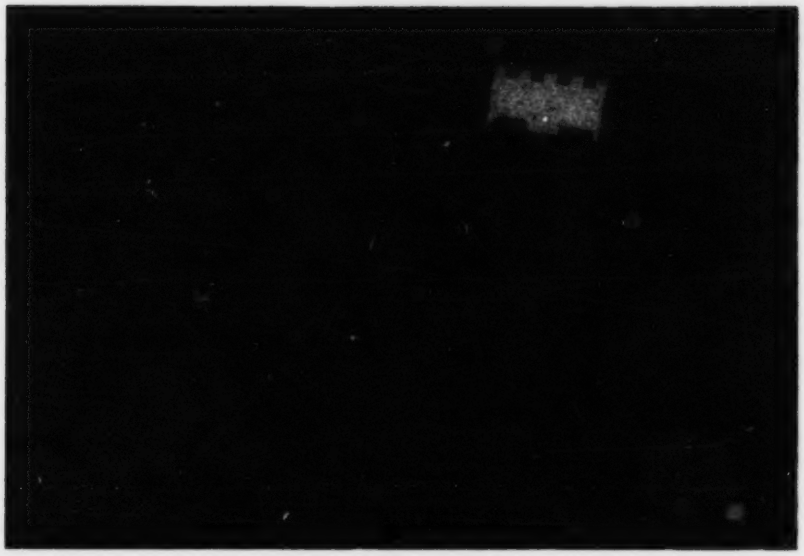

Photo 1. *Archean pillowed mafic volcanics of the Arsenic Lake formation, in the Net Lake area, Cassels Township.*

Photo 2. *Archean flow breccia in mafic volcanics, Arsenic Lake formation in the Net Lake area, Cassels Township.*

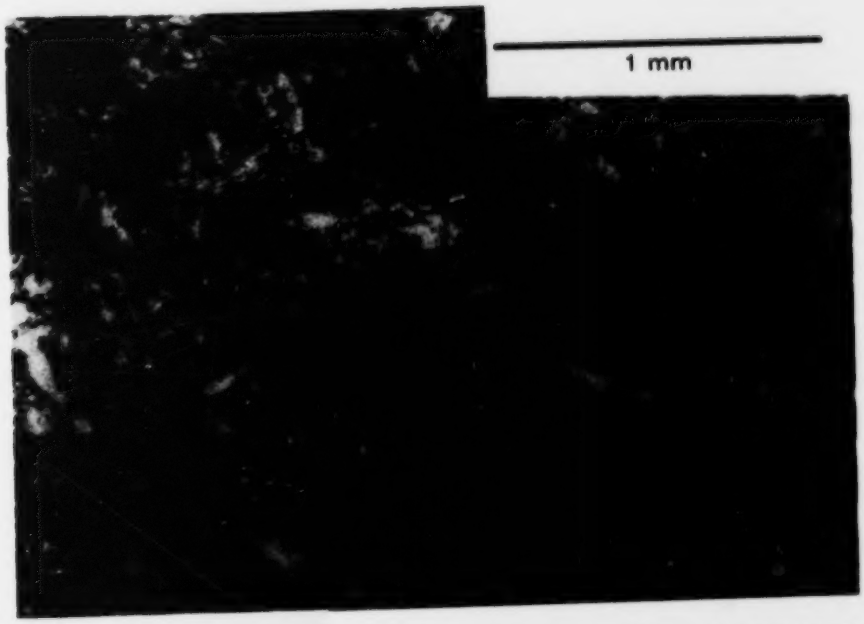

Photo 3. *Photomicrograph of Archean mafic to intermediate metavolcanics. Note felty and radiating actinolite and crenulated chlorite.*

Photo 4. *Photomicrograph of protomylonitic textures in Archean intermediate pyroclastic rocks.*

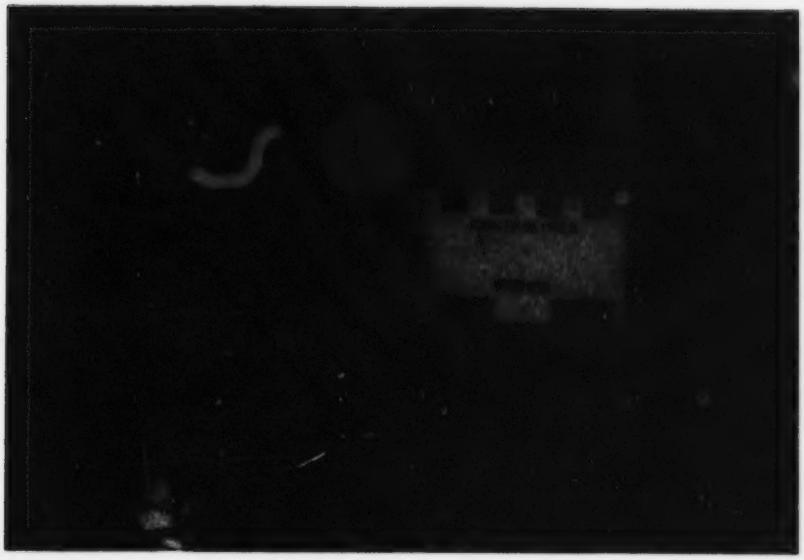

Photo 5. *Archean intermediate to felsic pyroclastic rocks: lapilli tuff, located in the Boot Bay area.*

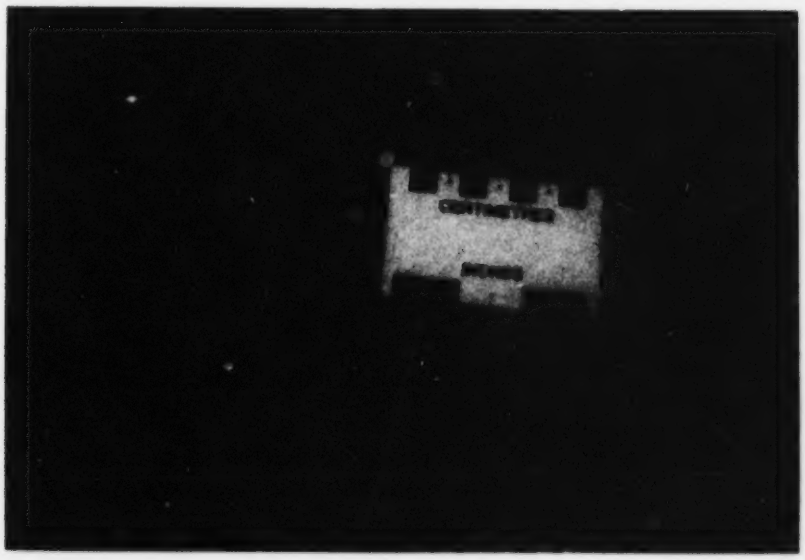

Photo 6. *Archean intermediate to felsic pyroclastic rocks: lapillistone, located in the Boot Bay area.*

gioclase and epidote. Actinolite, quartz and some opaque grains (sulphides) are also present. Mineral proportions of 40 to 50 percent hornblende (including some actinolite), 30 percent plagioclase and 10 to 30 percent epidote are common.

Hand specimens of greenschist rocks are generally schistose, fine grained and dark green in colour. In thin section, blastophitic (Photo 3), felty and cataclastic (Photo 4) textures are observed. Features such as partly milled rock fragments, pressure shadows and some kink banding are typical of some of the rocks within the LLDZ. Common lower greenschist facies metamorphic assemblages consist of 20 to 30 percent carbonate, 20 to 30 percent chlorite, 20 percent plagioclase (albite), 40 percent sericite, 5 percent actinolite, 5 percent clinozoisite/epidote and minor titanite and opaque minerals (sulphides and magnetite). Minor amygdules occur locally and contain quartz.

Carbonatization and chloritization of the mafic metavolcanic rocks is especially pervasive within the LLDZ, as illustrated by the volume and nature of carbonate crystals (probably calcite) which are oriented in patches parallel to schistosity but are clearly less deformed than the host matrix. Lepidoblastic, magnesium-rich chlorite crystals do, however, show crenulations indicative of several deformational events. Generally, plagioclase is saussuratized to a cloudy aggregate of clinozoisite/epidote, sericite and fine-grained, untwinned crystals of albite.

Weakly pleochroic green- to yellow-coloured actinolite constitutes 5 to 15 percent of the rock sample. It occurs as felty, radiating, acicular bundles with random crystal orientations (not parallel to schistosity) indicating growth subsequent to the main metamorphic event.

Contact metamorphic volcanic rocks are located adjacent to Nipissing diabase south of Sauvé Lake in Cassels Township. In hand specimens, the rocks consist of schistose to even-textured hornfels with abundant chlorite and epidote alteration. Petrographic studies indicate that the samples generally display granoblastic, recrystallized textures. Typical mineral assemblages consist of 5 to 20 percent plagioclase (albite), 0 to 30 percent chlorite, 0 to 30 percent epidote, 0 to 30 percent actinolite, 0 to 10 percent carbonate and minor magnetite and titanite. Plagioclase feldspars either have been altered to a cloudy aggregate of epidote or occur as untwinned albite crystals. Acicular, radiating bundles of actinolite crystals have replaced original pyroxenes and have mantled and overgrown original crystal boundaries.

Intermediate to Felsic Metavolcanics

Intermediate to felsic metavolcanic rocks (i.e., dacites, rhyodacites and rhyolites) have been recognized in the field on the basis of a combination of the following characteristics: colour, colour index, hardness, approximate specific gravity and lithostructure.

The rocks vary in colour from dark to light pink grey, yellow to pale yellow, and pale pink, and have a hardness of greater than six. Colour indices range from 15 to 35 percent for intermediate compositions to less than 15 percent mafic minerals for felsic metavolcanics (rhyolites). All of these rocks generally exhibit a well-developed, locally penetrative foliation.

Both pyroclastic rocks and flows have been recognized and where no obvious clastic textures were observed, the rocks were classified as fine-grained flows in the field. Subsequent thin section examinations revealed that some rocks mapped as flows are fine-grained pyroclastic rocks and only a small percentage of the felsic to intermediate rocks are now interpreted to be flows. Recognition of primary textures is further complicated by the overprinting of cataclastic textures affecting rocks within the LLDZ. Pyroclastic rocks have been subdivided according to Fisher (1966) and Easton and Johns (1986) on the basis of predominant grain size into tuff, lapilli tuff or crystal tuff. Fine-grained pyroclastic rocks are distinguished from fine-grained epiclastic rocks by: a) the absence of predominant argillaceous material; b) the occurrence of subhedral feldspar or ferromagnesium minerals similar to those in flows in a feldspathic rather than argillaceous matrix; and c) the similarity of weathering, alteration, hardness, mineralogy and chemical characteristics of pyroclastic units to nearby flows. Coarse-grained pyroclastic rocks can be subdivided into lapilli tuff, lapillistone, tuff-breccia and agglomerate based on the shapes (such as angular, subangular and rounded) and sizes of clasts of local volcanic rocks (essential fragments) set in a nonargillaceous tuffaceous matrix. Intermediate to felsic metavolcanic rocks comprise the major rock types in the middle portions of the Archean metavolcanic sequence exposed in the Lake Tetapaga syncline near the Boot Bay area of Cassels Township. They constitute the predominant rock types of the Link Lake formation (Fyon and Crockett 1986) in the area.

Pyroclastic rocks such as tuffs, quartz-feldspar crystal tuffs, lapilli tuffs (Photo 5) and lapillistones (Photo 6) as well as dacite, rhyodacite and rhyolite flows and slump breccias have been recognized in the area. Some aphanitic felsic rocks that were mapped as flows are probably structureless, fine-grained tuffs since no flow features were observed in thin section. Intermediate to felsic schists were also recognized and represent rocks which have undergone substantial shearing and deformation within the LLDZ.

Thin sections of four pyroclastic and five flow rocks were examined. All of them exhibited greenschist facies mineral assemblages and some showed evidence of minor cataclastic deformation. The felsic to intermediate flows are characterized by 30 to

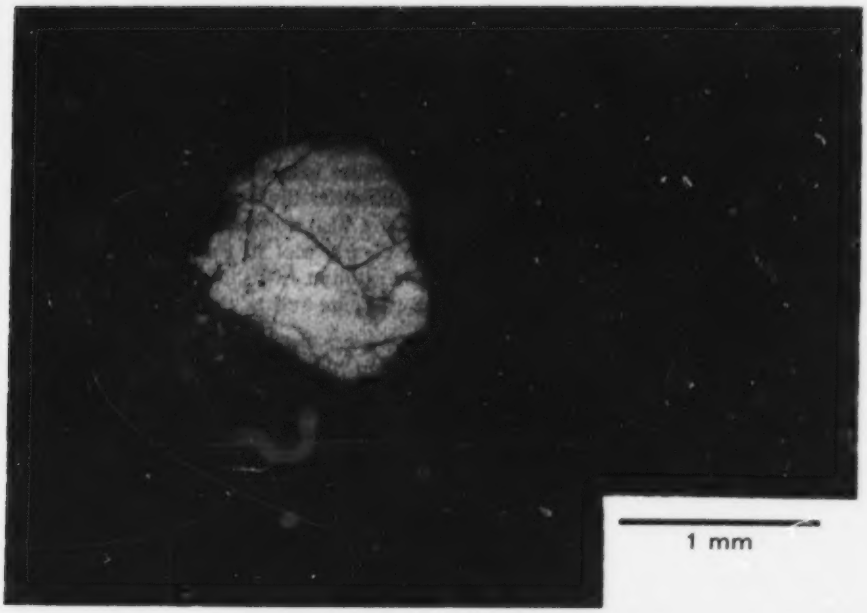

Photo 7. *Photomicrograph of Archean intermediate to felsic flows: note amygdules of quartz and epidote.*

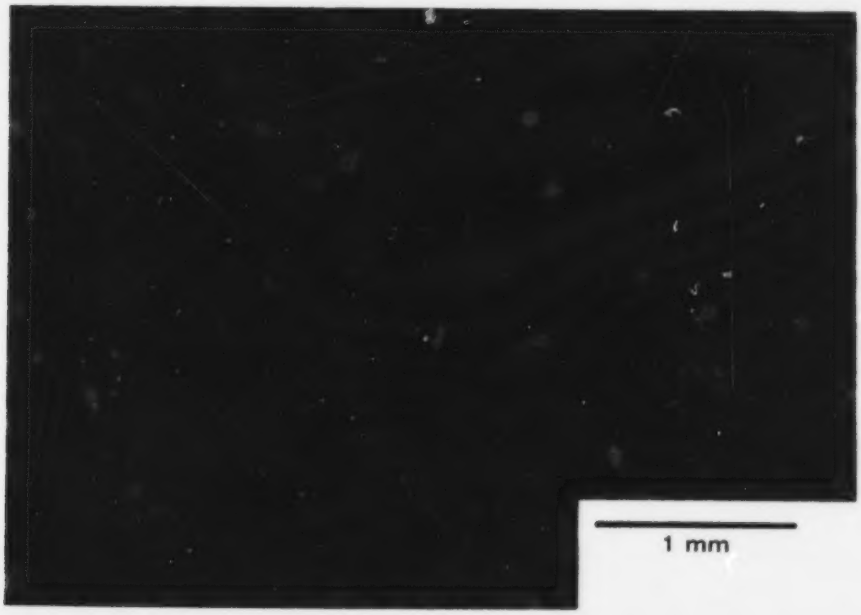

Photo 8. *Photomicrograph of Archean intermediate to felsic tuff pyroclastic rocks and felsic tuffs.*

70 percent plagioclase (this includes relict, altered and recrystallized untwinned albite crystal (An_{10})), 10 to 40 percent epidote/clinozoisite, 10 to 15 percent quartz, 5 to 15 percent chlorite (magnesium-rich variety), 5 percent carbonate, 0 to 10 percent muscovite/sericite and minor titanite and opaque minerals (sulphides). Epidote/clinozoisite and sericite are alteration products of plagioclase. Textures consist of a fine-grained intergrown matrix of plagioclase, epidote, chlorite and sericite with pilotaxitic relict plagioclase microlites and quartz crystals. Quartz and quartz-epidote amygdules constitute up to 10 percent of the rock (Photo 7). Narrow (1 to 2 mm) carbonate and quartz-carbonate veinlets commonly crosscut the earlier chlorite-sericite foliation.

Typically, the pyroclastic rocks contain 15 to 50 percent plagioclase (An_{10}), 5 to 40 percent quartz, 10 to 20 percent muscovite/sericite, 0 to 30 percent epidote and 0 to 20 percent carbonate with minor opaque minerals (pyrite and rutile). Epidote and sericite are alteration products of plagioclase. A planar fabric of chlorite and sericite enclose many of the larger fragments (Photo 8). In more cataclastic rocks, recrystallization is evident within pressure shadows adjacent to larger grains of quartz. Petrographic data indicate that the pyroclastic rocks contain more quartz and carbonate than corresponding flows. The proportion of feldspar to quartz is about 2:1 in pyroclastics, while in flows, it is 3:1. The high proportion of feldspar to quartz supports a pyroclastic rather than epiclastic origin since even in arkosic epiclastic rocks the percentage of quartz to feldspar is usually subequal.

Petrochemistry of Archean Metavolcanic Rocks

Samples from nineteen Archean metavolcanic rocks were collected for whole rock analyses which were provided by the Geoscience Laboratories, Ontario Geological Survey, Toronto. Table 2 lists the mafic to intermediate metavolcanics (Samples 1 to 7) in ascending stratigraphic order.

These are further subdivided into the following groups:

1. Samples 1 and 2 are from the OVC.
2. Samples 3 to 7 are from the YVC; with sample 3 from the Arsenic Lake formation, sample 4 from the Link Lake formation, and samples 5, 6 and 7 from the Upper formation.

Table 3 lists the intermediate to felsic metavolcanics (samples 8 to 19) in ascending stratigraphic order. All of them are from the Link Lake formation of the YVC.

The locations of the samples are given in Figure 3.

The geochemical data provide a basis to check rock classifications made in the field and to characterize them in terms of their chemical affinities.

In Figures 4 and 5, the analyses are illustrated on several plots commonly applied to volcanic rock data. All of the mafic to intermediate metavolcanic samples except one plot in the tholeiitic field of the Jensen cation plot (Figure 4) of Jensen (1976) and of a standard AFM weight percent diagram (Figure 5) of Irvine and Baragar (1971). The anomalous sample (Sample No. 5) which plots in the calc-alkalic field is a hydrous (4.70% LOI), high-alumina (19.80% Al_2O_3) andesite with silica (55.6% SiO_2) and titanium values (1.03% TiO_2) more characteristic of tholeiites than of calc-alkalic rocks. Elemental values are also comparable to the other six samples which clearly plot in the tholeiitic field. Therefore, sample number five should be considered a high-alumina tholeiite rather than a calc-alkalic rock.

Subdivision of the tholeiitic rocks using the Jensen cation plot (Figure 4), yields the following rock type classification:

1. Rocks from the OVC are magnesia-rich basalts.
2. Rocks from the Upper formation of the YVC are iron-rich tholeiitic basalts (Sample Nos. 6 and 7) and high-alumina tholeiitic andesites (Sample No. 5).
3. Mafic to intermediate flows from the Link Lake and Arsenic Lake formations of the YVC are tholeiitic andesites.

However, classification of the tholeiitic rocks under a scheme devised by Middlemost (1972), which uses the percentage of silica as a criterion, clearly shows that most of the samples are andesites containing greater than 53.5% SiO_2. Only one of the samples (Sample No. 3) is a basalt.

These results indicate that the mafic to intermediate metavolcanics represent a tholeiitic suite of rocks predominantly consisting of andesites with minor high-alumina andesite and basalt rock types.

In most cases the classification of rocks made in the field was confirmed by the chemical analyses. All samples of mafic to intermediate volcanics are tholeiitic. Andesites are the predominant rock type with an average value of 55% SiO_2. Intermediate to felsic metavolcanic flows and pyroclastic rocks are part of the calc-alkalic volcanic suite with an average value of 66% SiO_2. Dacites are the main rock types.

METAMORPHOSED MAFIC INTRUSIVE ROCKS

A body of coarse-grained gabbro, pyroxenite, amphibolite, and minor pillowed mafic volcanic rocks represent an Archean mafic volcanic-plutonic remnant in the Archean granitic terrane west of Pishabo Lake in Cassels Township.

The gabbro and pyroxenite are weakly foliated, medium to coarse grained and exhibit dark grey to black weathered surfaces. The more altered and foliated nature distinguishes these rocks from similar but younger Nipissing diabase rocks.

TABLE 2. CHEMICAL ANALYSES OF ARCHEAN MAFIC TO INTERMEDIATE METAVOLCANIC ROCKS, CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		1	2	3	4	5	6	7
Sample No.		5276*	5270	0142	0020	0099	0328	0919
Major Elements (wt%)								
SiO_2		52.30	54.60	52.30	55.20	53.00	48.90	49.00
Al_2O_3		12.40	13.10	13.90	14.40	18.90	12.30	14.40
Fe_2O_3		2.02	2.32	0.70	1.08	1.96	2.50	4.10
FeO		8.00	7.44	9.18	6.81	6.00	9.58	9.33
MgO		7.67	6.10	3.71	3.12	4.24	4.32	5.04
CaO		12.80	10.30	5.39	5.95	4.22	8.42	8.25
Na_2O		0.75	2.13	3.18	3.75	4.03	2.19	2.13
K_2O		0.26	0.64	0.40	0.71	1.15	0.07	0.20
TiO_2		0.41	0.49	1.62	1.18	0.98	1.21	1.85
P_2O_5		00.00	0.01	0.13	0.40	0.16	0.90	0.16
MnO		0.20	0.19	0.14	0.11	0.11	0.24	0.20
CO_2		0.19	0.35	0.11	4.22	2.26	4.66	0.33
S		0.03	0.07	0.01	0.01	0.01	0.10	0.14
H_2O^+		0.85	0.66	3.56	2.74	2.91	4.09	3.29
H_2O^-		00.00	00.00	0.14	00.00	0.10	0.10	00.00
LOI		1.30	0.90	6.90	6.30	4.70	7.80	2.90
Trace Element (ppm)								
Ag	AA	<2	<2				<2	<2
As	AA	1	01				4	7.5
Bi	AA	0.9	0.8				1.1	1
Co	AA	58	64	49	26	26	38	49
Cr	AA	1400	1500	215	87	88	193	193
Cu	AA	101	54	62	8	14	73	98
Ni	AA	310	335	41	56	72	50	78
Pb	AA	14	010	<10	<10	17	29	<10
Zn	AA	78	9	120	122	132	144	122
Be	ICP/OES	2	2	3	1	2	3	4
Co	ICP/OES	55	60	40	20	26	40	65
Cu	ICP/OES	105	55	85	9	19	85	115
Mo	ICP/OES	<10	<10	<10	<10	<10	<10	<10
Ni	ICP/OES	325	355	50	60	75	60	90
Sc	ICP/OES	45	55	65	30	30	45	40
Sr	ICP/OES	95	175	110	375	190	190	245
V	ICP/OES	240	270	305	130	130	325	355
Y	ICP/OES	15	18	22	30	20	35	40
Zn	ICP/OES	80	95	95	110	132	145	120
Hg (ppb)	AA	<20	<20			-	<20	<20
Au "	AA	2	2			-	<2	2
Pt "	AA	10	15			-	<1	1
Pd "	AA	14	18			-	-	<1
SiO_2% classed by SiO_2 content (anhydrous + adjusted wt%)		54.0 andesite	56.0 andesite	57.7 andesite	59.5 pillowed andesite	55.7 andesite	54.4 pillowed andesite	51.7 basalt

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-5276.*

TABLE 3. CHEMICAL ANALYSES OF ARCHEAN INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS, CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		8	9	10	11	12
Sample No.		0415*	0119	0118	0941	0265
Major Elements (wt%)						
SiO_2		56.70	66.80	59.40	61.00	73.20
Al_2O_3		17.70	15.80	16.30	15.10	13.40
Fe_2O_3		2.86	1.07	1.91	2.26	1.35
FeO		3.78	3.33	5.18	4.81	2.30
MgO		3.09	1.15	2.57	3.17	0.85
CaO		6.04	1.84	5.08	3.81	0.30
Na_2O		5.15	2.80	2.96	3.68	4.04
K_2O		0.54	2.39	0.98	0.47	2.06
TiO_2		0.78	0.71	0.91	0.93	0.61
P_2O_5		0.13	0.17	0.11	0.17	0.12
MnO		0.13	0.04	0.09	0.10	0.01
CO_2		0.20	1.93	1.11	0.50	0.25
S		0.01	0.02	0.07	0.01	0.01
H_2O^+		1.76	1.70	2.08	2.65	0.99
H_2O^-		0.09	0.12	0.07	0.07	0.11
LOI		1.70	2.60	2.80	2.60	1.70
Trace Element (ppm)						
Ag	AA		–	–	<2	
As	AA		–	–	2.5	
Bi	AA		–	–	1	
Co	AA	8	8	19	24	8
Cr	AA	86	<10	20	85	<10
Cu	AA	6	22	30	18	6
Ni	AA	64	<5	29	48	5
Pb	AA	12	2100	<10	20	<10
Zn	AA	72	65	94	95	40
Be	ICP/OES	1	1	1	1	1
Co	ICP/OES	<5	5	14	25	<5
Cu	ICP/OES	7	24	45	18	5
Mo	ICP/OES	<10	<10	<10	<10	<10
Ni	ICP/OES	65	<5	30	60	7
Sc	ICP/OES	22	14	19	18	10
Sr	ICP/OES	205	115	170	315	70
V	ICP/OES	120	17	110	135	24
Y	ICP/OES	15	45	20	30	24
Zn	ICP/OES	55	55	75	95	35
Hg (ppb)	AA	–	–	–	<20 B	–
Au "	AA	–	–	–	<2 B	–
Pt "	AA	–	–	–	1 B	–
Pd "	AA	–	–	–	<1 B	–
SiO_2% classed by SiO_2 content (anhydrous + adjusted wt%)		58.5 andesite	69.5 dacite	62.2 dacite	63.9 dacite	74.5 rhyolite

TABLE 3. (Continued)

Reference No.		13	14	15	16	17	18	19
Sample No.		0035	0036	0104	0334	0098	0317	0666
Major Elements (wt%)								
SiO_2		62.70	63.40	68.90	67.20	69.30	57.20	57.10
Al_2O_3		18.00	16.00	15.30	18.00	14.30	15.50	17.40
Fe_2O_3		1.43	0.94	2.48	1.21	2.73	1.04	2.22
FeO		4.15	5.11	1.04	0.92	1.78	6.59	4.56
MgO		1.98	3.24	0.74	0.93	1.02	4.74	2.03
CaO		1.21	1.79	1.34	0.75	1.51	2.97	5.51
Na_2O		4.49	1.82	3.04	4.74	2.76	2.10	1.26
K_2O		1.79	1.61	3.32	2.86	2.37	1.61	1.76
TiO_2		0.88	0.85	0.45	0.32	0.45	0.87	1.47
P_2O_5		0.18	0.19	0.09	0.16	0.07	0.12	0.29
MnO		0.06	0.05	00.00	00.00	0.01	0.09	0.16
CO_2		0.32	0.61	1.13	0.64	1.12	2.52	0.22
S		0.26	0.01	0.02	0.06	0.05	0.01	0.02
H_2O^+		2.20	2.60	0.90	1.39	1.00	3.46	1.63
H_2O^-		00.00	0.12	00.00	00.00	0.12	0.09	00.00
LOI		2.30	3.30	2.30	2.00	2.10	5.50	1.50
Trace Element (ppm)								
Ag	AA	–	–	–	<2		–	<2
As	AA	–	–	–	<1		–	8.5
Bi	AA	–	–	–	0.7		–	0.8
Co	AA	22	19	6	7	<5	25	26
Cr	AA	37	84	<10	30	<10	24	126
Cu	AA	24	59	6	13	7	6	18
Ni	AA	35	52	<5	10	<5	42	52
Pb	AA	<10	<10	<10	12	<10	<10	24
Zn	AA	90	114	22	20	17	160	124
Be	ICP/OES	1	2	<1	2	<1	1	2
Co	ICP/OES	18	15	<5	8	<5	18	30
Cu	ICP/OES	30	70	<5	11	6	7	19
Mo	ICP/OES	<10	<10	<10	<10	<10	<10	<10
Ni	ICP/OES	40	55	<5	17	<5	50	65
Sc	ICP/OES	11	20	<10	3	7	14	30
Sr	ICP/OES	130	130	60	125	80	80	195
V	ICP/OES	80	140	25	45	17	110	220
Y	ICP/OES	18	15	8	6	23	5	35
Zn	ICP/OES	180	100	22	22	18	135	125
Hg (ppb)	AA	–	–	–	<20		–	125
Au "	AA	–	–	–	120		–	<20
Pt "	AA	–	–	–	<1		–	2
Pd "	AA	–	–	–	<1		–	<1
SiO_2% classed by SiO_2 content (anhydrous + adjusted wt%)		64.6 dacite	66.7 dacite	71.3 rhyolite	69.2 dacite	72.0 rhyolite	61.6 dacite	59.0 andesite

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-0415.*

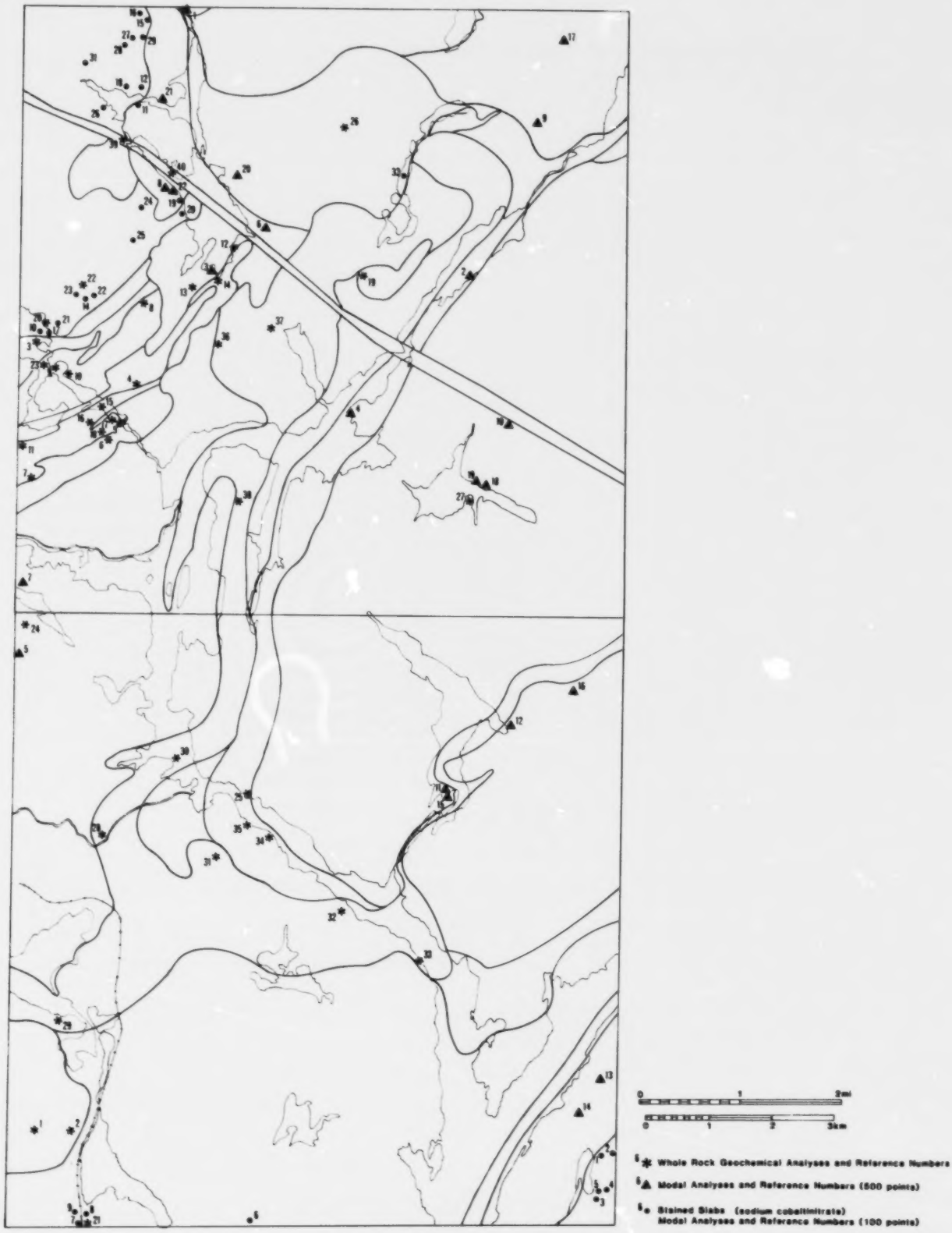
0 1 2mi
0 1 2 3km
Whole Rock Geochemical Analyses and Reference Numbers
Modal Analyses and Reference Numbers (500 points)
Stained Slabs (sodium cobaltinitrate)
Modal Analyses and Reference Numbers (100 points)

Figure 3. *Location map for chemically analyzed samples; modal data from thin sections of rock samples; and modal data from stained (sodium colbaltinitrate) rock slabs of Archean felsic plutonic rocks.*

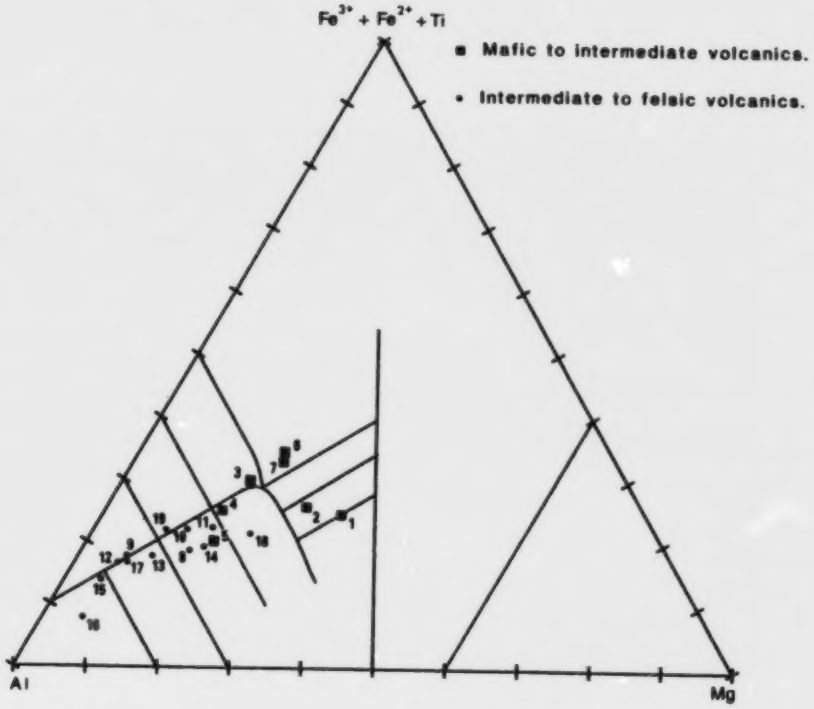

Figure 4. *Jensen cation plot - Archean metavolcanic rocks of Cassels and Riddell townships.*

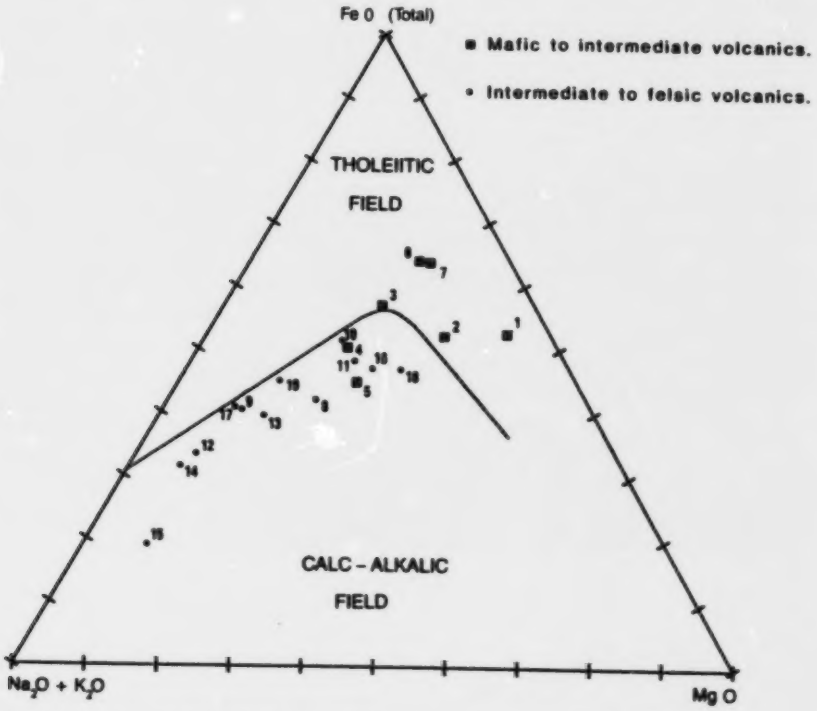

Figure 5. *AFM (weight percent) plot - Archean metavolcanic rocks of Cassels and Riddell townships.*

Photo 9. *Border zone of the Archean Strathy batholith with a partly digested pillow basalt remnant.*

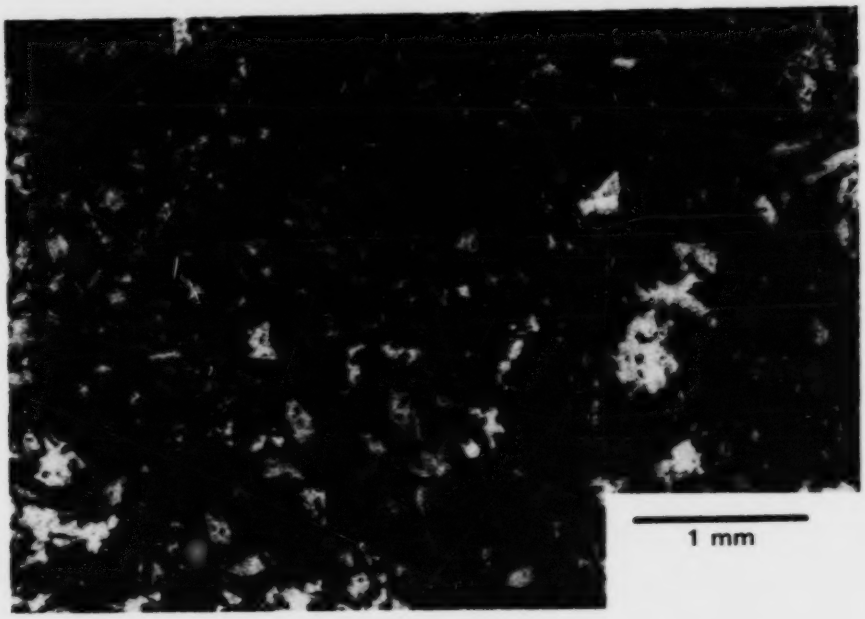

Photo 10. *Photomicrograph of Archean diabase dike rock. Note well-developed subophitic textures.*

Petrographic study indicates that blue-green hornblende, biotite and plagioclase are the main mineral phases. Epidote, chlorite, sericite and opaque minerals (2 to 10 percent magnetite) also occur. Relict subophitic textures (blastophitic textures) are evident with amphiboles having replaced, mantled and overgrown original pyroxene crystal boundaries. Epidote and sericite are alteration products of plagioclase.

FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Archean felsic plutonic rocks underlie most of the northwest corner of Cassels Township and occur also along the south margin of Riddell Township. These plutonic rocks were emplaced at least 2500 Ma (Van Schmus 1965). Field relations indicate that the local granitic rocks are clearly intrusive and are younger than the Archean metavolcanic rocks as they contain inclusions of these metavolcanic rocks within their margins.

Massive, coarse-grained leucocratic granites are the predominant rocks with lesser granodiorite and quartz monzodiorite varieties. A contaminated border zone is locally present and contains up to 50 percent mafic xenoliths within a granodiorite host (Photo 9). Nomenclature of the granitic rocks follows that proposed by Streckeisen (1976).

Typically, the felsic plutonic rocks are coarse-grained, massive and leucocratic with only 2 to 5 percent biotite present. Weathered and fresh surfaces are usually red and pink to grey in colour. Variation in rock colour is due to hematitization and original compositional differences (i.e., the proportion of plagioclase to alkali feldspar). Identification of alkali and plagioclase feldspar was facilitated by the cutting and staining with sodium cobaltinitrate of 31 specimens. The results as listed in Table 4 are plotted in Figure 6 and indicate approximately two-thirds of the samples are granites with lesser granodiorite and quartz monzodiorite varieties. Sample locations are given for these samples in Figure 3. In a few samples, some of the pink feldspars were intensely iron-stained plagioclase rather than alkali feldspar. Subsequent thin section examinations of several samples confirmed that plagioclase is locally altered and contains fine dust-like hematite staining.

Typical granitic mineral assemblages consist of 20 to 35 percent quartz, 15 to 35 percent plagioclase (An_{30}), 5 to 50 percent microcline, 5 to 10 percent muscovite, 2 to 5 percent biotite, 2 to 10 percent epidote and minor chlorite, titanite and hematite.

Textures are generally hypidiomorphic granular with strained quartz crystals exhibiting undulatory extinction. Epidote and sericite are alteration products of plagioclase indicating alteration under greenschist metamorphic conditions. Minor mortar textures indicate some recrystallization of the original hypidiomorphic granular minerals. Minor amounts of secondary chlorite are present.

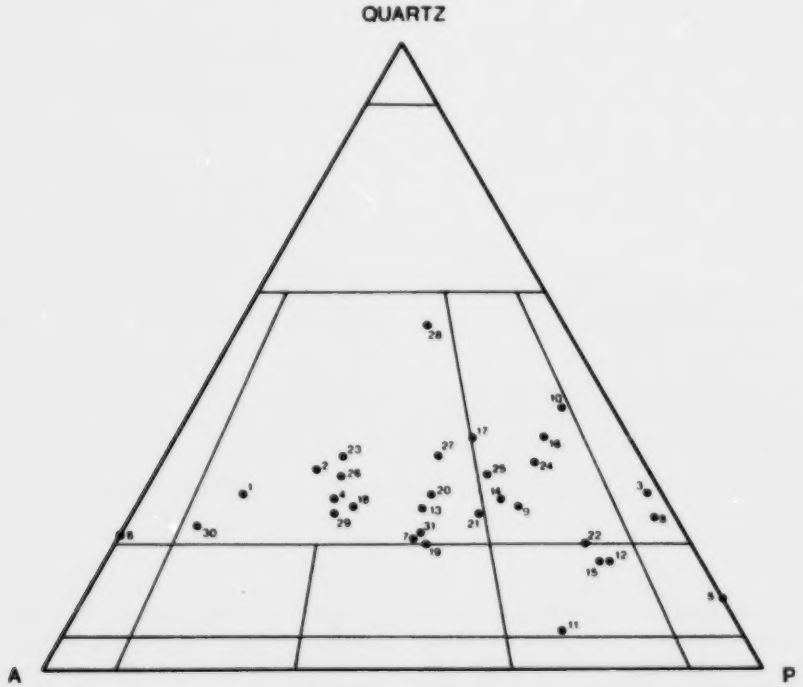

Figure 6. *Streckeisen ternary QAP diagram - Archean felsic to intermediate plutonic rocks.*

TABLE 4. MODAL ANALYSES OF ARCHEAN GRANITOID ROCKS CASSELS AND RIDDELL TOWNSHIPS.

Sample No.	Number on Figure	Quartz (Q)	Alkali Feldspar(A)	Plagioclase Feldspar (P)	Classification
2165(h)*	1	28	14	58	Granite
2190(h)	2	32	46	22	Granite
2194(h)	3	28	2	70	Tonalite
2195(h)	4	27	46	27	Granite
2196(h)	5	11	0	89	Quartz Diorite
2629	6	21	79	0	Alkali Granite
5043	7	21	38	71	Granite
5200(h)	8	24	3	73	Tonalite
5201(h)	9	26	21	53	Granodiorite
0134	10	42	7	51	Granodiorite
0176(h)	11	6	25	69	Quartz Monzodiorte
0178	12	17	13	70	Quartz Monzodiorte
0320a	13	66	12	22	Granite
0454(h)	14	27	23	50	Granodiorite
2561	15	17	14	69	Quartz Monzodiorte
2565	16	37	12	51	Granodiorite
0134	17	37	22	41	Granodiorite
0180	18	26	44	30	Granite
0227	19	20	15	65	Granodiorite
0229	20	28	32	40	Granite
0409	21	25	27	48	Granite
0454	22	20	15	52	Granodiorite
0460	23	34	41	25	Granite
0599(h)	24	33	15	52	Granodiorite
0636	25	31	23	46	Granodiorite
0747	26	31	43	26	Granite
2580	27	34	28	38	Granite
2581	28	55	19	26	Granite
2585	29	25	47	28	Granite
2753b	30	23	67	10	Granite
4853	31	22	37	41	Granite

Note: Each sample's percentage Q, A, P, is based on 100 point counts of a stained slab, plotted on Figure 6. Locations are given in Figure 3.
(h) denotes Hematitized samples.

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-2165.*

Along the north shore of Net Lake in Cassels Township where shearing and hematitization are pervasive, local chlorite- and pyrite-bearing quartz veins intrude the leucogranites.

A contaminated border zone separates the Archean metavolcanic sequence from the main body of massive felsic plutonic rock west of Pishabo Lake in Cassels Township. In these zones, up to 70 percent of the rock consists of angular xenolithic blocks of mafic material (1 to 3 m size) hosted in a granodiorite (*see* Photo 9).

In the vicinity of Pishabo Lake, several fine-grained ("felsite") and medium-grained aplitic dikes cut the coarse-grained plutonic rocks. The dikes are pink coloured and 10 cm to 1 m wide. In thin section, the mineral assemblage consists of 35 percent plagioclase (albite), 30 percent quartz, 15 percent muscovite, 5 percent chlorite, 3 percent biotite, 2 percent titanite and 2 percent opaque minerals. Plagioclase laths form slightly porphyritic to granoblastic textures in a fine-grained equigranular matrix of quartz and feldspar.

Chemical analyses and norms of Archean felsic plutonic rocks are shown in Table 5.

MAFIC INTRUSIVE ROCKS

North- and northwest-trending mafic dikes commonly intrude the felsic plutonic rocks in northwest Cassels Township, west of Pishabo Lake. The dikes consist of diabase and minor lamprophyre and plagioclase porphyritic diabase which are referred to as Matachewan diabase dikes by Todd (1925). Dikes are generally 1 to 3 m wide but reach a maximum of 70 m and are traceable for 200 to 400 m. Typically,

TABLE 5. CHEMICAL ANALYSES AND NORMATIVE MINERALS OF ARCHEAN FELSIC TO INTERMEDIATE PLUTONIC ROCKS; CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		20	21
Sample No.		0146*	5042
(Major Elements (wt%)			
SiO_2		72.60	65.50
Al_2O_3		13.90	16.00
Fe_2O_3		0.93	1.83
FeO		1.85	2.25
MgO		1.00	1.80
CaO		1.56	3.01
Na_2O		3.20	3.47
K_2O		2.87	2.32
TiO_2		0.36	0.60
P_2O_5		0.06	0.14
MnO		0.03	0.05
CO_2		0.38	0.23
S		0.01	0.01
H_2O^+		0.74	0.46
H_2O^-		0.09	00.00
LOI		1.30	1.70
Trace Elements (ppm)			
Ag	AA		<2
As	AA		2
Bi	AA		0.2
Co	AA	7	12
Cr	AA	<10	28
Cu	AA	6	13
Ni	AA	<5	20
Pb	AA	<10	31
Zn	AA	48	40
Be	ICP/OES	1	<1
Co	ICP/OES	<5	15
Cu	ICP/OES	5	14
Mo	ICP/OES	<10	<10
Ni	ICP/OES	<5	30
Sc	ICP/OES	4	10
Sr	ICP/OES	125	360
V	ICP/OES	16	70
Y	ICP/OES	19	12
Zn	ICP/OES	40	45
Hg (ppb)	AA		<20 B
Au "	AA		<2 B
Pt "	AA		<1 B
Pd "	AA		<1 B
Rock Name		granite	granodiorite

Reference No.	20	21
Sample No.	0146	5042
CIPW Norms		
APTT	0.34	0.14
PYRT	0.00	0.00
ILMN	1.17	0.69
ORTH	14.10	17.18
ALBT	30.21	27.42
ACMT	0.00	0.00
ANRT	12.93	5.01
SPHN	0.00	0.00
RUTL	0.00	0.00
MGNT	2.73	1.37
HEMT	0.00	0.00
DIOP	0.00	0.00
HEDN	0.00	0.00
WOLL	0.00	0.00
ENST	4.61	2.52
FERS	1.77	2.12
QRTZ	28.34	38.92
FORS	0.00	0.00
FAYA	0.00	0.00
PVSK	0.00	0.00
NEPH	0.00	0.00
LEUC	0.00	0.00
DICA	0.00	0.00
KALP	0.00	0.00
CNDM	3.27	3.76
CALC	0.54	0.88
NPLG	29.97	15.44
FEMG	0.06	0.04
RMG	0.77	0.61
RFE	0.23	0.39
C.I.	10.29	6.70

All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-0146.

the diabase are massive and fine to medium grained with dark grey-green-coloured fresh and weathered surfaces.

In thin section, the mineral assemblages consist of 35 percent actinolite (weakly pleochroic yellow and green), 20 percent plagioclase, 15 to 20 percent epidote, 10 percent quartz, 10 percent granophyre (plagioclase and quartz intergrowth), 5 percent chlorite, 3 percent titanite and lesser opaque grains. Subophitic textures are common with actinolite replacing and rimming original pyroxene. Plagioclase is altered and replaced by epidote and minor chlorite (Photo 10). These dike rocks are compositionally similar to younger Nipissing diabase rocks; both contain characteristic granophyre typical of varied textured Nipissing diabase.

Lamprophyre dikes are uncommon and constitute only 10 to 20 percent of all Archean mafic dikes. Commonly, they consist of dark grey-green-coloured aggregates of amphibole, biotite and plagioclase in a medium-grained equigranular mosaic. Dikes are usually 2 to 3 m wide and traceable for 200 to 300 m. A thin section examination indicates the lamprophyre contains 50 percent tremolite, 20 percent chlorite, 10 percent carbonate, 5 percent plagioclase, 3 to 5 percent titanite and minor rutile.

TABLE 6. CHEMICAL ANALYSES AND NORMATIVE MINERALS OF ARCHEAN MAFIC DIKE ROCKS, CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		22	23
Sample No.		0477*	0132
Major Element (wt %)			
SiO_2		44.70	47.40
Al_2O_3		7.59	23.90
Fe_2O_3		2.30	2.42
FeO		11.70	4.52
MgO		16.40	3.34
CaO		8.75	9.28
Na_2O		0.51	1.61
K_2O		0.60	2.28
TiO_2		1.11	0.62
P_2O_5		0.13	0.03
MnO		0.25	0.14
CO_2		0.62	1.21
S		0.03	0.01
H_2O^+		4.02	2.61
H_2O^-		0.14	0.09
LOI		4.40	4.20
Trace Elements (ppm)			
Co	AA	77	15
Cr	AA	955	99
Cu	AA	230	7
Ni	AA	900	31
Pb	AA	28	33
Zn	AA	235	66
Be	ICP/OES	2	1
Co	ICP/OES	60	11
Cu	ICP/OES	310	8
Mo	ICP/OES	<10	<10
Ni	ICP/OES	800	35
Sc	ICP/OES	20	30
Sr	ICP/OES	50	180
V	ICP/OES	170	125
Y	ICP/OES	19	10
Zn	ICP/OES	195	50

Reference No.	22	23
Sample No.	0477	0132
CIPW Norms		
APTT	0.33	0.07
PYRT	0.00	0.00
ILMN	2.23	1.22
ORTH	3.75	13.93
ALBT	4.56	14.08
ACMT	0.00	0.00
ANRT	17.59	39.48
SPHN	0.00	0.00
RUTL	0.00	0.00
MGNT	3.52	3.63
HEMT	0.00	0.00
DIOP	13.50	0.00
HEDN	5.25	0.00
WOLL	0.00	0.00
ENST	23.07	8.60
FERS	10.29	5.72
QRTZ	0.00	5.49
FORS	9.69	0.00
FAYA	4.76	0.00
PVSK	0.00	0.00
NEPH	0.00	0.00
LEUC	0.00	0.00
DICA	0.00	0.00
KALP	0.00	0.00
CNDM	0.00	4.95
CALC	1.49	2.84
NPLG	79.42	73.71
FEMG	0.58	0.13
RMG	0.75	0.66
RFE	0.25	0.34
C.I.	72.30	19.16

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-0477.*

Textures are typically fine grained (0.6 mm size), equigranular and granoblastic. Plagioclase is a minor constituent and is largely replaced by chlorite.

Plagioclase porphyritic diabase dikes are most common in an area 1300 m west of the northwest corner of Pishabo Lake and along the north shore of Net Lake, both in Cassels Township. Most of these 30 to 40 m wide dikes trend in a predominant northwest and lesser northeast direction and are traceable for up to 400 m. Typically dark green, fresh and weathered surfaces exhibit 10 to 20 percent glomeroporphyritic plagioclase knots (1 to 2 cm size) in a medium-grained groundmass. Plagioclase crystals also occur as oikocrysts (2 to 4 cm size) with well-defined crystal boundaries in a fine- to medium-grained matrix. Petrographic examination indicates mineral assemblages consisting of 0 to 25 percent actinolite, 25 to 40 percent epidote, 0 to 20 percent muscovite, 20 to 25 percent chlorite, 0 to 15 percent relict plagioclase, 5 to 10 percent quartz, 5 percent carbonate, 3 to 5 percent titanite and 1 to 3 percent magnetite. Porphyritic textures are common with 0.4 to 4 cm sized plagioclase phenocrysts in a 0.08 to 0.1 mm fine-grained matrix. Epidote and sericite are alteration products of plagioclase.

Of the four thin sections from mafic intrusive rocks, all exhibit greenschist metamorphic mineral assemblages.

Chemical analysis of representative samples are presented in Table 6 and plotted in figures 7 and 8.

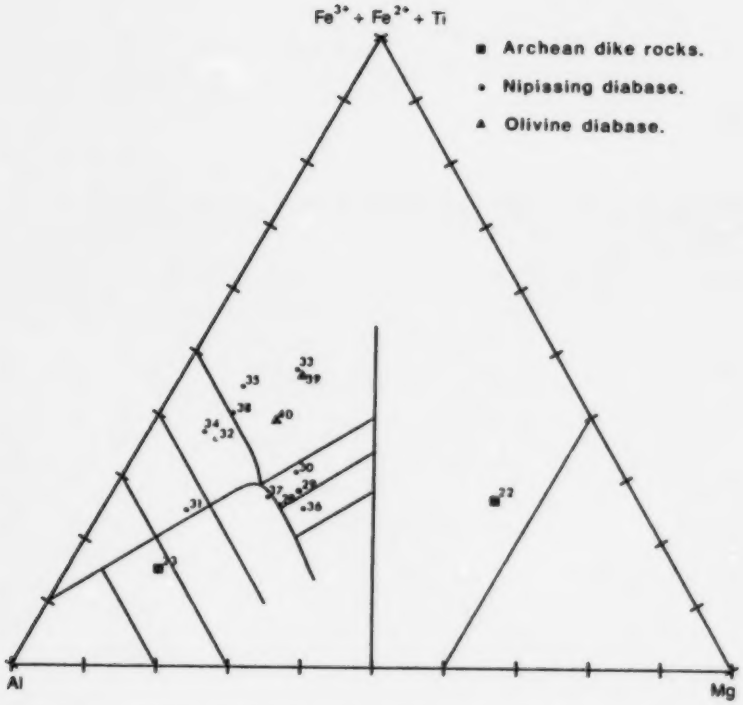

Figure 7. *Jensen cation plot - Archean mafic dike rocks, Early Proterozoic Nipissing diabase and Middle Proterozoic olivine diabase dikes (Sudbury Swarm) from Cassels and Riddell townships.*

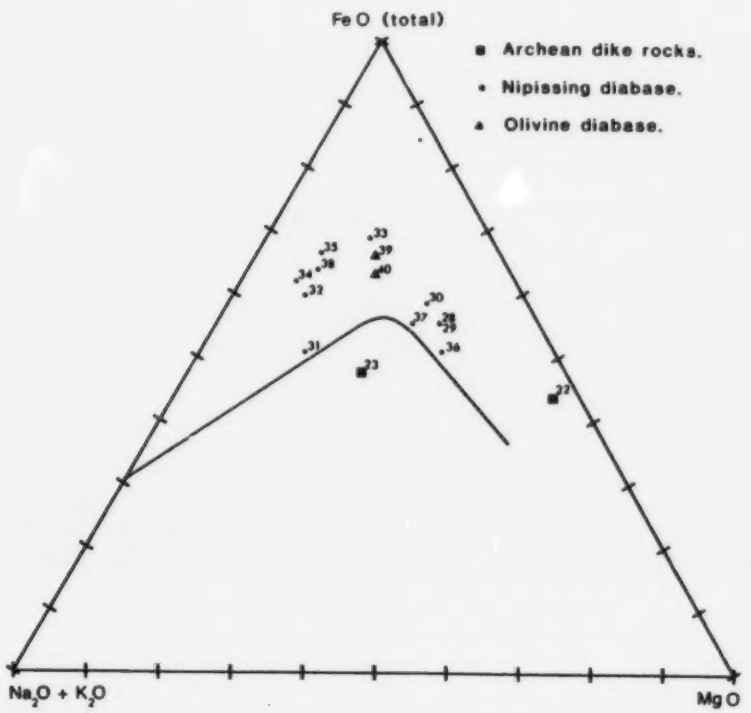

Figure 8. *AFM (weight percent) plot - Archean mafic dike rocks, Early Proterozoic Nipissing diabase and Middle Proterozoic olivine diabase dikes (Sudbury Swarm) from Cassels and Riddell townships.*

EARLY PROTEROZOIC

HURONIAN SUPERGROUP

Rocks of the Huronian Supergroup were deposited between 2500 Ma (the age of the Archean plutons) and 2160 Ma, the age of Nipissing diabase intrusions (Van Schmus 1965).

Rocks of the Huronian Supergroup underlie most of the area. They consist of clastic sediments of the Gowganda and Lorrain formations of the Cobalt Group. With a thickness of up to 3600 m the Cobalt Group is more prominent than other Huronian groups with respect to aerial distribution and thickness (Miller and Knight 1906). It consists of the Gowganda, Lorrain, Gordon Lake and Bar formations. The latter two formations are missing from the Cassels and Riddell map area.

Gowganda Formation

The Gowganda Formation (Collins 1917) has long been known for its glacial origin and distinctive yet diverse rock types. It is a heterogeneous sequence of conglomerate, pebbly wacke, arkose and siltstone which covers an area extending from Sault Ste. Marie (Frarey 1977) to Cobalt (Donaldson et al. 1985). The estimated thickness of the formation is 1000 m in the Maple Mountain area (west of Temagami) (Card et al. 1973), 1200 m in the Sudbury–Espanola area (Card et al. 1977) and 860 m in the Cobalt area (Thomson 1957).

In the present map area, the Gowganda Formation is made up of a lower unit, the Coleman Member, and an upper unit, the Firstbrook Member.

COLEMAN MEMBER

Rocks of the Coleman Member are mainly located in the western half of the map area. They are approximately 500 m to 600 m thick and overlie Archean basement rocks. They consist of a local basal breccia of angular granitic clasts overlain by matrix- and lesser clast-supported, granitic clast conglomerates. Both rock types rapidly grade upwards into the predominant Coleman Member rock type of pebbly wacke which probably represents debris flow material. Locally, laminated to thinly bedded mudstones, pebbly mudstones and siltstones, and pebbly arkoses are intercalated with massive to thickly bedded pebbly wacke. This represents deposition in lower energy conditions between successive debris flow episodes. Sedimentary rocks of the Coleman Member are characterized by rapid lithofacies changes and the presence of "dropstones". The smaller "dropstones" show no disruption of the underlying bedding whereas cobble size ones sometimes produce impact features in the underlying beds. Ripple marks are also common in some of the finer-grained rock types of the Coleman Member.

Contacts between the Coleman Member and the overlying Firstbrook Member are poorly exposed but appear to be conformable and abrupt. The transition is marked by the disappearance of granitic clasts and/or 1 to 2 mm size quartz grains within the rocks and by abrupt lithologic and bedding changes to laminated grey to maroon siltstones with lenticular sand beds of the Firstbrook Member.

Pebbly Wacke

Pebbly wackes are usually massive to thickly bedded and contain 2 to 15 percent clasts greater than 2 mm in size. This predominant debris flow lithology of the Coleman Member has been subdivided into coarse-grained, pebbly wacke (unit 6a), and fine-grained, silty pebbly wacke (unit 6b). Pebbly arenites (unit 6d) also occur but are less common than wackes. Silty, pebbly wackes contain approximately 40 to 50 percent silt detritus in the matrix as opposed to 15 to 20 percent in the regular pebbly wacke. Clasts are generally in the 4 to 64 mm size range but some are greater than 256 mm (boulder size). Granitic clasts are most common but metavolcanic and metasedimentary clasts also occur (Photo 11). Mud armoured granitic clasts are rare but do occur within pebbly wackes along the north shore of Pishabo Lake (Photo 12). These features are considered indicative of current traction which caused the granitic clasts to roll in soft bottom mud.

Pebbly wackes have characteristic green-grey fresh and weathered surfaces and contain an average of 5 to 10 percent pebbles. Readily identifiable sand-size fragments are angular, poorly sorted and set in a fine-grained matrix. In thin section, the wackes consist of subrounded grains of quartz, feldspar and rock fragments (0.1 mm size) set in a fine-grained (<0.06 mm) silty matrix of chlorite, muscovite and silt-size quartz and feldspar detritus (Photo 13). These wackes are mainly classified as feldspathic lithwackes because of the large percentage of feldspar and rock fragments within the slightly dispersed framework. Modal analyses of these rocks are listed together with other clastic rocks from the Gowganda and Lorrain formations in Table 7 and plotted in Figure 9. A representative chemical analysis is presented in Table 8.

Arkose, Pebbly Arkose, Pebbly Arkosic Wacke

Arkoses occur locally in the lower section of the Coleman Member in the vicinity of Pishabo Lake in Cassels Township. They occur as medium- to thick-bedded units intercalated with pebbly wackes. Arkoses exhibit characteristic light grey-pink-coloured weathered and fresh surfaces. Petrographic examination indicates a range of sedimentary compositions from subarkosic lithwacke to lithic arkose; arkose; and subarkosic wacke. Most of the five samples examined (Figure 9) have a moderate percentage of rock fragments and feldspar detritus with the ratio of plagioclase to microcline at approximately 1:1. Most samples are transitional between true

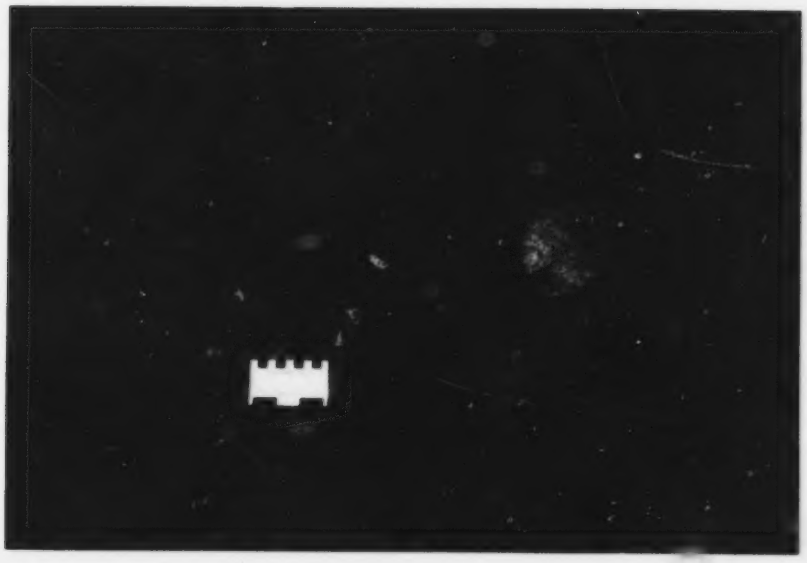

Photo 11. *Pebbly wacke - Coleman Member of the Gowganda Formation.*

Photo 12. *Armoured granitic clasts - Coleman Member of the Gowganda Formation.*

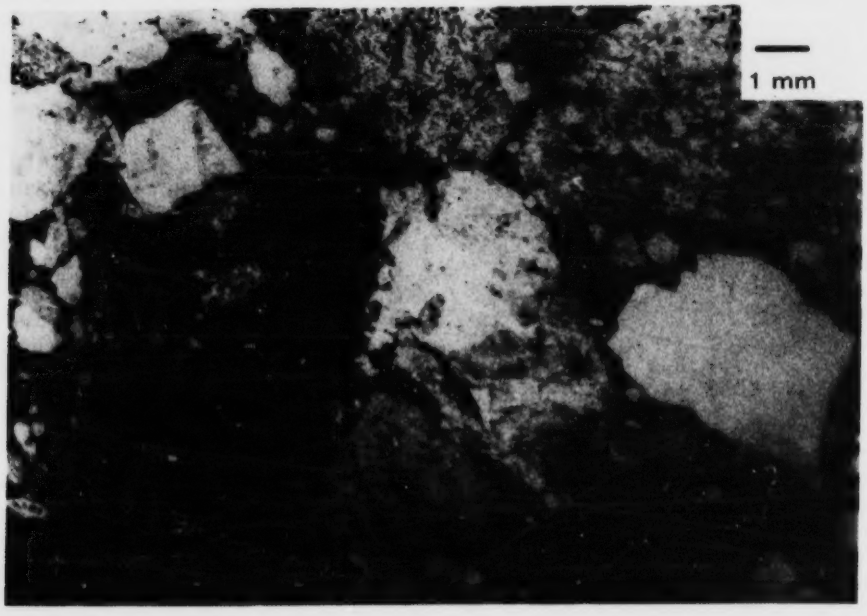

Photo 13. *Photomicrograph of a pebbly wacke of the Coleman Member, Gowganda Formation.*

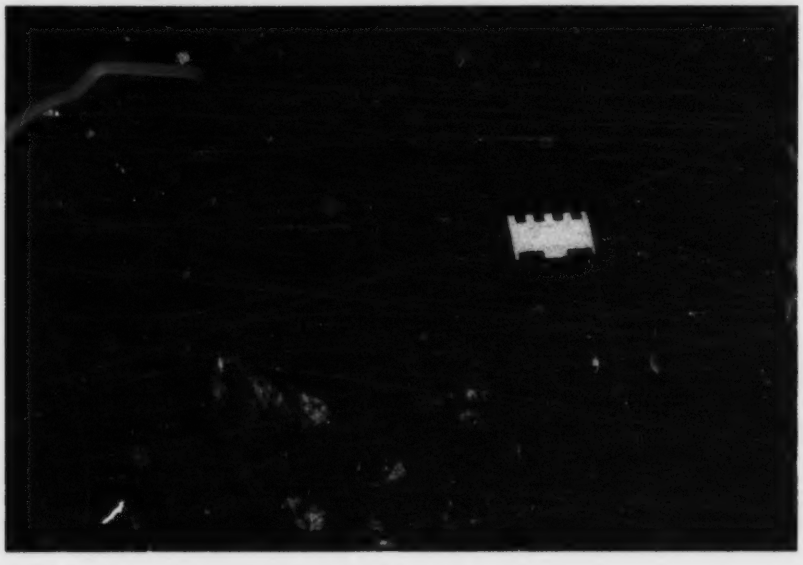

Photo 14. *Basal breccia - Coleman Member of the Gowganda Formation.*

TABLE 7. MODAL ANALYSES OF SEDIMENTARY ROCKS, LORRAIN AND GOWGANDA FORMATIONS, CASSELS AND RIDDELL TOWNSHIPS.

Specimen No.	Reference No.	Quartz[1]	Feldspar[1]	Rock[1] Fragments	"Matrix"[2] %	Petrographic Classification (Figure 6)	Probable original composition prior to diagenetic and/or low-grade metamorphic alterations
Rock Fragments > 15% of Total Counts							
Lorrain Formation							
162B*	1	16.9	11.6	71.4	24.5	Feldspathic Lithwacke	Same
0312	2	44.3	22.9	32.8	41.6(E)	Feldspathic Lithwacke	Lithic arkose
Gowganda Formation Firstbrook Member							
0289	4	66.3	16.3	17.4	4.0	Lithic Subarkose	Same
Coleman Member							
0262A	3	45.7	20.9	33.4	22.2	Feldspathic Lithwacke	Same
4255	5	56.5	15.7	27.8	24.0	Feldspathic Lithwacke	Same
0039	6	34.4	14.3	51.3	69.2	Feldspthic Lithwacke	Same
4173	7	51.4	3.1	45.4	23.4	Lithwacke	Same
0200A	8	48.0	33.6	18.4	-	Lithwacke	Same
Rock Fragments <15% of Total Counts							
Lorrain Formation							
4898	9	85.4	14.6	-	-	Subarkose	Subarkose
4389	10	16.9	11.6	-	29.6(E)	Quartz wacke	Arkose
2234	11	86.9	13.1	-	68.0(E)	Subarkosic wacke	Arkose
2309	12	86.6	13.4	-	28.4(E)	Subarkosic wacke	Arkose
2136	13	77.6	21.1	1.3	60.1(E)	Subarkosic wacke	Arkose
2141	14	78.4	18.0	3.6	28.9(E)	Subarkosic wacke	Arkose
2233	15	77.1	16.3	6.6	17.8(E)	Subarkosic wacke	Arkose
2333	16	98.7	1.3	-	47.6(E)	Quartz wacke	Arkose
2737	17	78.9	21.2	-	62.0(E)	Subarkosic wacke	Arkose
4331	18	84.5	-	15.5	35.0(E)	Sublithic wacke	Arkose
4332A	19	97.4	-	2.6	37.6(E)	Quartz wacke	Arkose
Gowganda Formation Firstbrook Member							
0253	20	69.6	14.5	15.9	31.0(E)	Subarkosic wacke	
Coleman Member							
0173	21	74.8	17.5	7.7	21.0	Subarkosic wacke	Same
0200B	22	51.2	48.8	-	-	Arkose	Same

1. Listed as Q, F and RF co-ordinate for QF, RF ternary plot (Figure 9), the sum of these framework components totals 100%.

2. Matrix defined as fine-grained fraction (<30 microns) and is listed as percentage of total counts of each rock. In the case of all samples from the Lorrain Formation "matrix" includes substantial muscovite epimatrix and/or lesser chlorite and muscovite cement in addition to minor protomatrix (original matrix).

3. When a large percentage of epimatrix is present then a probable original composition rock composition is given.

(E) - indicates substantial muscovite epimatrix which resulted from the breakdown of feldspars and represents diagenetic and/or low-grade metamorphic effects. This is most evident in rocks from the Lorrain Formation and with rocks from the Firstbrook Member of the Gowganda Formation.

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-162B.*

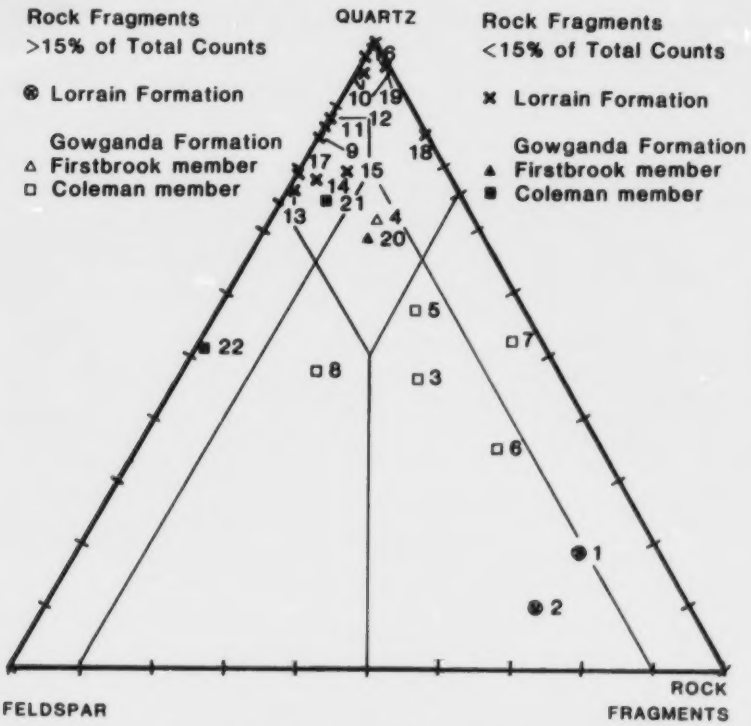

Figure 9. *QFR ternary plot to show the variation in mineralogical composition of sedimentary rocks from the Coleman Member and Firstbrook Member of the Gowganda Formation, and the Lorrain Formation.*

wackes and sandstones with greater than 15 percent interstitial matrix (<0.06 mm, silt size) between a dispersed framework of subrounded grains (0.2 mm size) of quartz, feldspar and rock fragments. Typical mineral assemblages also contain chlorite, muscovite and epidote which are indicative of lower greenschist metamorphic conditions (Winkler 1976).

Mudstone, Pebbly Mudstone, Siltstone and Claystone

Several sequences of thinly bedded mudstone and siltstones are found just below the upper contact of the Coleman Member. Typically, the rocks are weakly schistose with grey-green fresh and weathered surfaces. One sample revealed upon petrographic examination to be entirely composed of clay (<0.004 mm size) with some associated minor muscovite, chlorite and several rounded clay balls (1 mm size). Colour variations throughout the thin section outline and highlight millimetre-scale bedding as found in most siltstone and claystone lithologies.

Outcrops of mudstones were in all cases stratigraphically overlain by pebbly wackes and as such were considered part of the Coleman Member rather than the overlying Firstbrook Member.

Common features such as slump structures, loading features, ripple marks and graded bedding are found in many of the mudstone exposures.

Conglomerates

The conglomeratic lithologies within the Coleman Member are only found in areas which directly overlie the Archean basement. Thick, massive conglomerate beds are neither extensive nor commonly traceable between outcrops. Most of the conglomerates are unsorted, heterolithic, matrix-supported, pebble conglomerates with a wacke matrix. The volume of framework clasts ranges between 15 to 50 percent with the majority of conglomerates having between 20 to 25 percent framework clasts. Lithic clasts range in size from about 2 mm to 25 cm and consist of granitic and lesser volcanic and gneissic lithologies. Clasts are generally subangular to subrounded in shape.

Clast-supported conglomerates are rare and consist of rocks with >50 percent framework clasts (2 to 256 mm size). Framework clasts are usually subrounded and consist of granites and lesser volcanic rocks.

Basal Breccia

An exposure of the contact of the Gowganda Formation with the Archean rocks was observed at one locality of Pishabo Lake in Cassels Township. The

TABLE 8. CHEMICAL ANALYSES OF SEDIMENTARY ROCKS FROM THE GOWGANDA AND LORRAIN FORMATIONS, CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		24	25	26	27
Sample No.		4238*	2005	0040	4316
Major Elements (wt%)					
SiO_2		63.30	60.90	58.70	80.10
Al_2O_3		17.20	17.90	18.80	10.60
Fe_2O_3		2.53	2.79	3.61	1.67
FeO		5.18	4.59	4.59	0.59
MgO		2.83	2.78	3.12	0.52
CaO		2.23	0.90	0.60	0.19
Na_2O		3.95	2.86	2.47	0.20
K_2O		1.83	2.53	3.44	3.20
TiO_2		0.59	0.77	0.72	0.34
P_2O_5		0.19	0.14	0.15	0.04
MnO		0.07	0.10	0.04	00.00
CO_2		0.13	0.39	0.82	0.11
S		0.12	0.01	0.01	0.01
H_2O^+		2.59	2.81	2.84	1.08
H_2O^-		00.00	0.10	0.12	00.00
LOI		2.70	3.10	3.30	1.80
Trace Elements (ppm)					
Co	AA	29	26	26	5
Cr	AA	126	144	162	28
Cu	AA	24	26	22	5
Ni	AA	49	62	67	13
Pb	AA	12	<10	20	<10
Zn	AA	84	84	62	<5
Be	ICP/OES	2	2	2	<1
Co	ICP/OES	22	19	19	<5
Cu	ICP/OES	25	40	25	<5
Mo	ICP/OES	<10	<10	<10	<10
Ni	ICP/OES	55	70	70	13
Sc	ICP/OES	15	18	17	2
Sr	ICP/OES	340	105	65	55
V	ICP/OES	100	105	120	35
Y	ICP/OES	10	15	7	<5
Zn	ICP/OES	70	70	55	<5
Location		Gowganda Fm. Coleman Member	Gowganda Fm. Firstbrook Member	Gowganda Fm. Firstbrook Member	Lorrain Fm.
Rock Type		pebbly wacke	arenite	laminated mudstone, arenite	arkose

All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-4238.

basal lithology consists of a clast-supported and angular granite cobble breccia with a 15 percent wacke matrix (Photo 14). No evidence of regolith development was observed in the underlying Archean rocks. The general shape and distribution of the clasts suggests that the angular blocks were possibly produced by frost heaving.

Petrographic examinations reveal that the conglomerate matrix consists of a subarkosic wacke with a subrounded, dispersed framework of 20 percent plagioclase feldspar and 50 percent quartz grains. Interstitial to the framework is a matrix made up of chlorite and silt-size detritus which makes up 30 percent of the rock.

Metamorphosed Rocks

Metamorphosed rocks of the Coleman Member are found near Nipissing diabase east of Lower Twin Lake, along the southern boundary of Riddell Township. They consist of recrystallized wacke with abundant chlorite and epidote and granoblastic textures.

FIRSTBROOK MEMBER

The Firstbrook Member of the Gowganda Formation conformably overlies the Coleman Member, and is located near the shores of Rabbit, Cassels and Obashkong lakes in both Cassels and Riddell townships. Its thickness generally ranges from 100 m to 200 m except in the northern part where it is 400 m thick. Elsewhere to the north, the estimated thick-

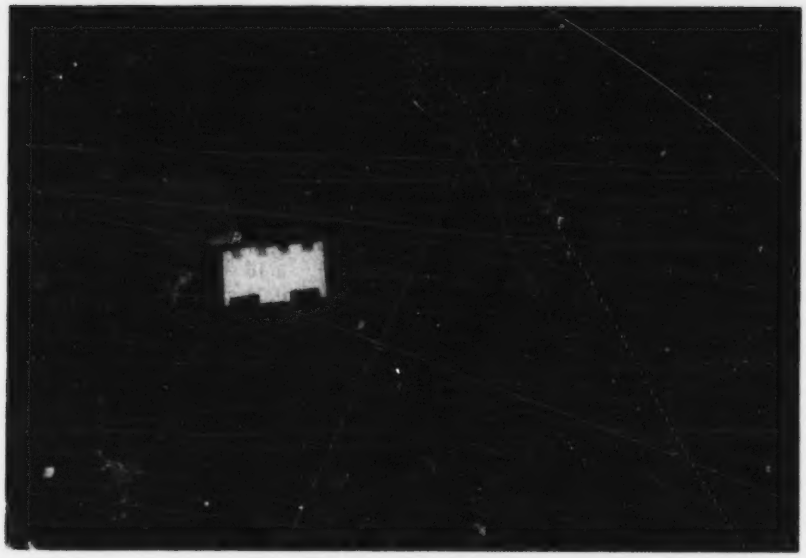

Photo 15. *Laminated mudstones and siltstones - Firstbrook Member of the Gowganda Formation.*

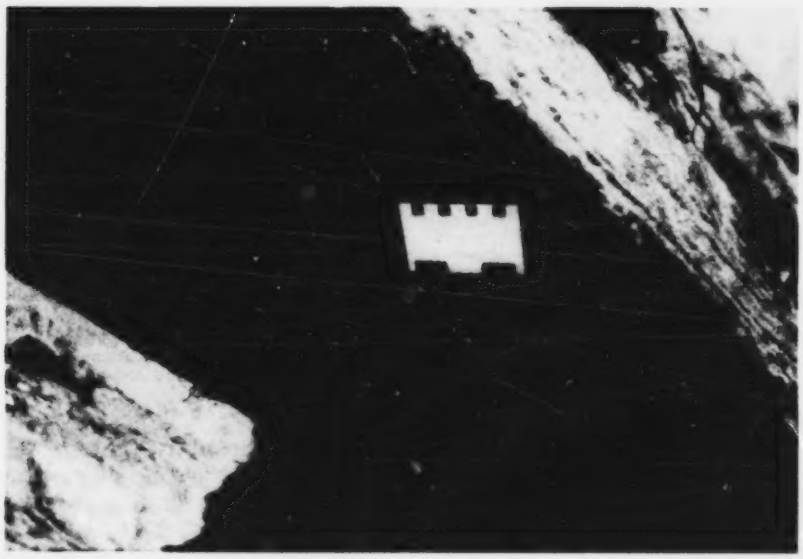

Photo 16. *Ripple marks in laminated mudstone and arenite - Firstbrook Member of the Gowganda Formation.*

ness of the member is 485 m at the "type location" in Firstbrook Township (Johns 1985).

Contacts between the Firstbrook Member and the overlying Lorrain Formation are conformable and gradational over vertical distances of 10 to 20 m except in one locality along the northern edge of the map area (Petraut Lake) where a local angular unconformity has been observed by the author.

Firstbrook Member lithologies consist of interlaminated (shaley) mudstones, siltstones and very fine grained arenite with some thinly bedded arkose, and minor wacke or turbiditic beds locally intercalated within the sequence (Photo 15). In the thickest section located in the north, the lithologies consist mainly of laminated to massive arenites containing abundant rock fragments interlaminated with minor mudstones. This lithology corresponds to the upper part of the Firstbrook Member.

Generally the lower part of the member consists of shaley mudstones with minor siltstone interbeds. The middle and upper parts, however, consist of an interbedded sequence of shaley mudstone, siltstone and very fine grained arenite that represents a coarsening upward cycle in which the proportion of arenite interbeds increases with increasing stratigraphic height. Lenticular sand beds and starved ripples are other common features.

Sedimentary structures such as tabular cross-laminations, ripple marks (Photo 16), wavy bedding, graded bedding, soft sediment deformation, rip-up clasts and ball and pillow structures are well developed within the grey- to maroon-coloured sediments of the Firstbrook Member. All paleocurrent indicators show transportation directions from the north.

Thin section studies of the arenites from the Firstbrook Member indicate a dispersed framework with well-sorted, subrounded to subangular grains (0.08 mm size) of quartz, feldspar (>15 percent) and opaque minerals surrounded by a fine-grained groundmass (<30 micron size) of chlorite and muscovite which usually constitutes approximately 20 percent of the rock (*see* Figure 9).

This fine-grained mass consists of a muscovite epimatrix which resulted from the breakdown of labile feldspar grains, and muscovite and chlorite cement surrounding many of the framework grains. Such modification probably occurred during diagenesis and/or low-grade metamorphism. Most thin sections contain greater than 15 percent fine-grained material, however, since very little of this represents protomatrix (original matrix material) the rocks are classified as arenites or subarkoses rather than wackes.

The mudstone beds consist of 5 percent opaque grains (>0.06 mm) in a predominant matrix of intergrown chlorite, muscovite, silty quartz and feldspar, and rare carbonate, all less than 0.06 mm in size. Graded bedding, cross-lamination and soft sediment deformation (slumping) are also observed in thin section (Photo 17).

Metamorphosed sediments of the Firstbrook Member are found near Nipissing diabase north of Sauvé Lake in Cassels Township. Here epidote and chlorite are abundant in the slightly recrystallized, and granoblastic, massive to laminated arenites and siltstones. Otherwise, the contact metamorphosed sediments have retained much of the original sedimentary characteristics.

Several chemical analyses (Sample Nos. 25, 26) of representative arenites of the Firstbrook Member are presented in Table 8.

Lorrain Formation

Arkoses of the Lorrain Formation (Miller 1910; Miller and Knight 1906) conformably overlie the Firstbrook Member of the Gowganda Formation and locally cover the eastern half and northern margins of the map area.

In Cassels and Riddell townships the formation has an average thickness of 600 to 700 m whereas in the Maple Mountain area to the west of Temagami, it is 1500 m thick (Card et al. 1973).

The Lorrain Formation in the eastern Cobalt Embayment has been subdivided into three members which are in ascending order: a lower feldspathic arenite; a middle less feldspathic arenite; and an upper quartz arenite member (Collins 1917; Rice 1986). A more complicated seven member subdivision of the Lorrain Formation was suggested by Card et al. (1973). The local lithologies found in Cassels and Riddell townships fit into Collins (1917) lower feldspathic arenite member and into the lower green sandstone member of the Card et al. (1973) classification.

The basal member of the Lorrain Formation, as interpreted by Card et al. (1973) has been mapped by Johns (1985) in Firstbrook Township and by the author in the present map area as the thin upper part of the Firstbrook Member. This was done because these rocks form a transition zone which more closely resemble lithologies of the Firstbrook Member than those of the Lorrain Formation. The base of the Lorrain Formation is defined by the first appearance of thickly bedded (30 to 100 cm), greenish fine-grained arkoses interbedded with minor laminated mudstone and siltstone beds (Photo 18). The arkose consists of well-sorted, very fine to fine-grained sand (Figure 9 and Table 7) with abundant feldspar and rock fragments. This basal unit grades upwards into a fine- to medium-grained arkose which commonly exhibits tabular (Photo 19) and trough (Photo 20) crossbeds and minor graded bedding. All paleocurrent directions indicate transport from the north.

In thin section, the arkose consists of well-sorted, subrounded quartz and feldspar grains (0.2 to 1 mm) which form a framework surrounded by

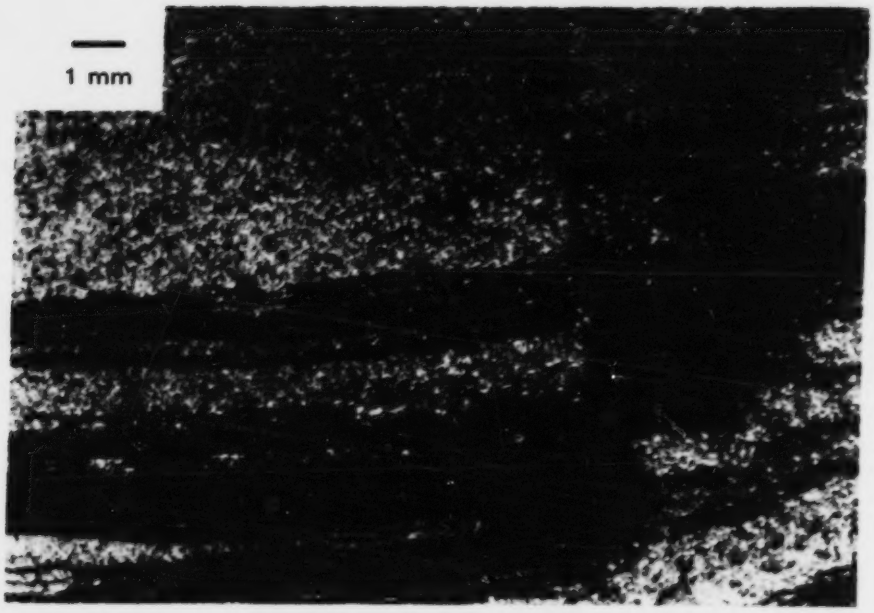

Photo 17. *Photomicrograph of graded bedding and soft sediment deformation in laminated mudstone and arenite of the Firstbrook Member of the Gowganda Formation.*

Photo 18. *Transition zone - basal Lorrain Formation, mudstone interbedded with medium-bedded arkose.*

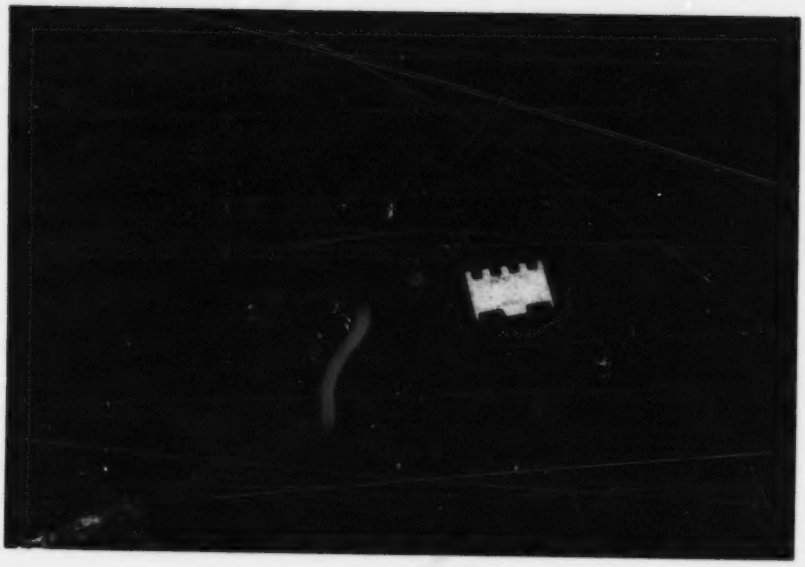

Photo 19. *Tabular crossbeds - Lorrain Formation.*

Photo 20. *Trough crossbeds - Lorrain Formation.*

fine-grained chlorite and muscovite (Photo 21), the volume of which constitutes up to 50 percent of the rock. Most of this represents diagenetic alteration such as epimatrix and cement rather than original protomatrix material.

An interbedded sequence of both fine- and coarse-grained arkoses define the overlying stratigraphic unit. The fine-grained lithologies consist of green, well-sorted, micaceous arkose forming 3 to 10 cm beds. These are intercalated with thickly bedded, trough cross-bedded, heterolithic and moderately sorted lithic arkose made up of coarse sand-sized detritus and abundant rock fragments. Such a sequence may represent a series of "stacked" amalgamation (erosional) surfaces in either a fluvial or marine depositional environment as proposed by Rice (1986).

In the northern Cobalt embayment, similar, fine- and coarse-grained interbedded sequences have been described by Rice (1986) as:

> Finer-grained detrital beds represent recessive weathering, and micaceous 'capping' units separating coarser-grained arenite beds.

Within the map area, this unit containing the recessive weathering, micaceous beds constitutes a fairly continuous and traceable map unit (unit 8d) in the eastern part of Cassels and Riddell townships. On strike with this unit are coarse-grained and micaceous, green-coloured, lithic arkoses intercalated with lesser reddish-coloured, coarse-grained and micaceous, hematitized arkoses.

In thin section, both the hematitized arkose and the greenish, lithic arkose have a moderately sorted framework of subrounded grains of quartz and variable amounts of rock fragments in a matrix containing hematitized muscovite which constitutes more than 50 percent of the rock. This "matrix" consists mainly of muscovite epimatrix as a result of the breakdown of feldspars and surrounds the framework grains. The proportion of original matrix (protomatrix) is probably less than 15 percent of the rock. No remnant feldspar framework grains have survived the diagenetic and/or low-grade metamorphic alteration. The greenish, lithic arkoses contain approximately 15 percent rock fragments whereas the hematitized arkoses have from 0 to 3 percent rock fragments.

Stratigraphically overlying these lithologies along the eastern edge of the map area are greenish, coarse-grained arkoses. These are similar to corresponding arkoses found at lower stratigraphic levels except that the former consist of well-sorted, very fine grained sand whereas the upper unit consists of moderately sorted, mainly coarse sand.

Thus, within the Lorrain formation a coarsening upward cycle of very fine grained arkose up to coarse-grained arkose can be defined over a vertical distance of approximately 600 to 700 m in the eastern half of the map area. However, this is but a continuation of a larger coarsening upward cycle which also includes the entire 200 m local thickness of the Firstbrook Member of the Gowganda Formation. In total this represents a vertical distance of approximately 900 m in which the detrital grain size ranges from clay and silt-sized at the base of the Firstbrook Member to coarse sand-sized arkoses in the uppermost parts of the lower Lorrain Formation along the eastern margin of the map area.

A representative chemical analysis of an arkose from the Lorrain Formation (Sample No. 27) is presented in Table 8.

Metamorphosed rocks of the Lorrain Formation occur along Sunrise Lake in Riddell Township. Recrystallized subarkosic wackes have greyish-green-coloured fresh and weathered surfaces and exhibit massive, fine- to medium-grained, granoblastic textures. Both chlorite and recrystallized feldspar clots have locally developed within arkoses adjacent to Nipissing diabase. In thin section, these samples contain highly sutured, quartz and feldspar framework grains. The subrounded dispersed framework grains are set in a fine-grained mass of chlorite, muscovite and silt-size (<0.06 mm) detritus which makes up greater than 20 percent of the rock. Within the proximal zone of contact metamorphism, blotches (1 to 4 mm size) and veinlets of alkali feldspar occur along with circular, 1 mm size green chlorite aggregates. Mineral proportions of 40 percent chlorite and 40 percent alkali feldspar are common and as a result the arkoses have the appearance of mottled, or spotted hornfels. Effects of the contact metamorphism appear to be localized to within 10 to 20 m of the diabase at this locality. Elsewhere the sedimentary rocks have not been affected by the dike. A more detailed examination of the contact metamorphic effects at this locality is being undertaken by Peter MacEachern (1987) in the form of a BSc thesis.

Spotted chlorite alteration also occurs in rocks of the Gowganda Formation in the Cobalt area. Some early investigators attributed this alteration to the emplacement of the silver-cobalt veins (Owsiacki 1984). Other investigators, however, relate this phenomenon to the emplacement of Nipissing diabase (Jambor 1971).

DEPOSITIONAL ENVIRONMENTS OF THE HURONIAN ROCKS

Various studies of the Gowganda Formation have been undertaken by Schenk (1965), Lindsey (1969), Miall (1983, 1985), Donaldson et al. (1984, 1985) and others. Features that support a clear glacial origin are well summarized in Schenk (1965). Some of these glacial features include: a) the lack of an Archean regolith beneath the formation; b) the presence of "dropstone" and other ice-rafted pebbles and cobbles; and c) the large volume of matrix-supported versus clast-supported conglomerates within the formation.

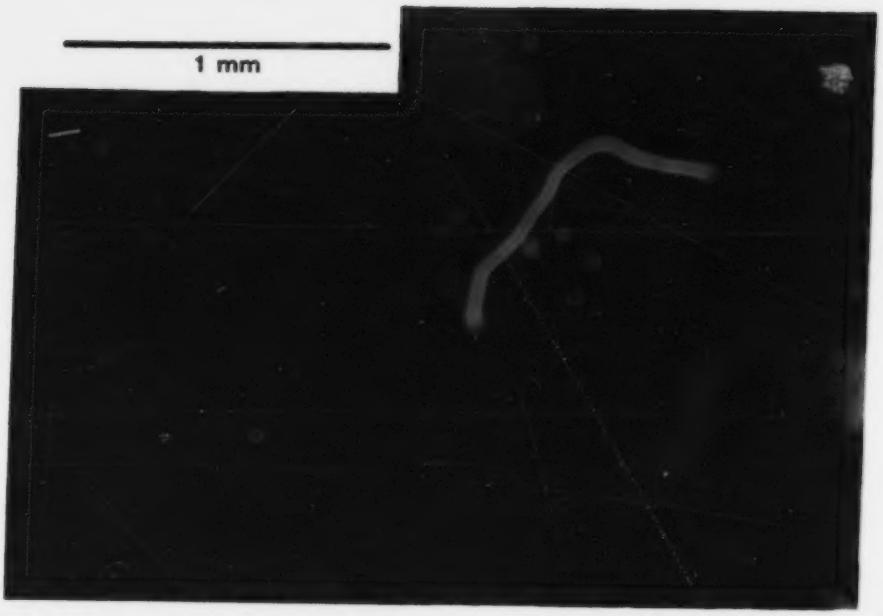

Photo 21. *Photomicrograph of a typical arkose of the Lorrain Formation. Note the subangular to subrounded nature of the framework grains set in a groundmass of sericite; most of which represents epimatrix. This is a result of diagenesis and the breakdown of labile framework feldspar grains, not true matrix, i.e., protomatrix.*

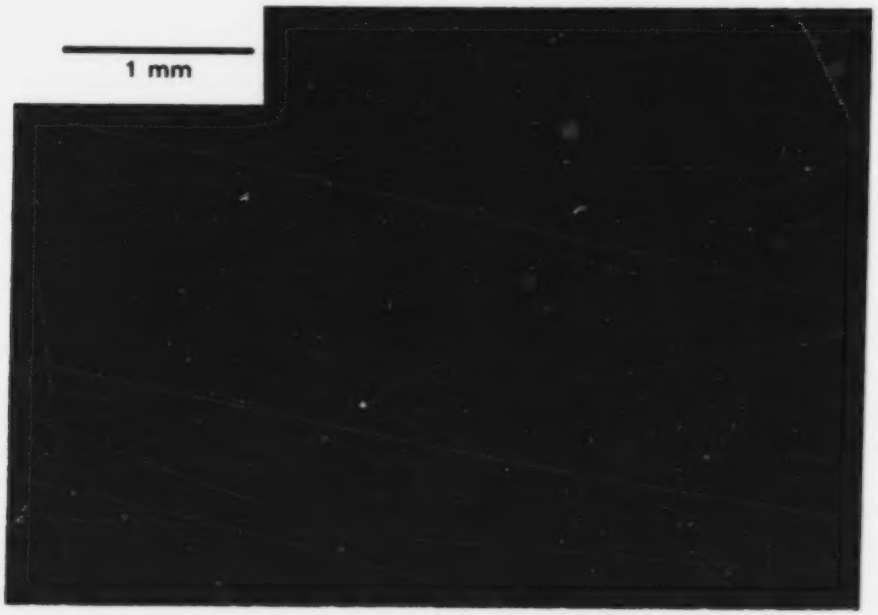

Photo 22. *Photomicrograph of granophyric intergrowth of alkali-feldspar and quartz in a varied textured diabase - Nipissing diabase. Sample location is at the Temagami-Lorraine occurrence (Property 4).*

However, Card et al. (1977) and Miall (1983, 1985) suggest that some of the features present cannot be explained by glaciation without the influence of redeposition of some of the sediments. Many of the matrix-supported conglomerates and pebbly wackes probably represent extensive debris flows in a largely marine environment with associated turbidity currents, channelization, scouring and redeposition playing an important role.

Various depositional models have been proposed, all of which recognize a major glacial influence during deposition. Differences basically concern whether deposition occurred in a purely continental glacial facies (i.e., grounded ice facies) or that of a marine glacial facies (Eyles and Miall 1984).

The following is a summary of key field relations of the sedimentary rocks of the Coleman Member in the map area, and how these have been interpreted by the author to fit into a depositional model:

1. The basal breccia represents a periglacial regolith of Archean granites.
2. Matrix-supported conglomerates (diamictites) usually overlie the Archean rocks. Their massive, heterolithic nature and stratigraphic position at the base of the sequence probably indicates a debris flow origin rather than direct deposition as a primary till.
3. Overlying the basal breccia are bedded to massive pebbly wackes with locally important siltstone and arkose beds. These lithologies could have been deposited in a marine glacial environment in which sedimentation occurred in a basin in direct contact with the ice margin and thus received substantial volumes of sediment directly from melt water conduits and subaqueous fans. Sections of interbedded mudstone, siltstone and arenite represent deposition from repeated interaction of sediment plumes and tidal currents (Eyles and Miall 1984).

Thus, deposition of rocks of the Coleman Member (Gowganda Formation) is inferred to have occurred mainly as debris flows near an inter-shelf grounded ice sheet. Subsequent subaqueous deposition of finer-grained sediments occurred in a glaciomarine tidewater environment.

The depositional environment of the Firstbrook Member within the map area is probably not glacial but a river-dominanted, deltaic environment similar to that proposed by Donaldson et al. (1985) and Rainbird (1985) for the South Lorrain area. Sedimentological comparisons tend to support deposition in a marine basin influenced by weak tidal and oceanic currents.

Thinly laminated mudstones probably represent a deep water deposition by suspended load rainout in a prograding deltaic environment.

Laminated mudstones, siltstones and arenites were deposited by a combination of turbidity flow and suspension load rainout within the delta slope environment. The presence of variegated hematitic mudstone and siltstones suggests a shallow water environment with wavy and rippled cross-laminated sediments which indicate currents from the north. As the overlying Lorrain Formation is approached, the volume of rippled laminated mudstone decreases and bed thickness increases but the sedimentary lithologies are similar.

The basal part of the Lorrain Formation consists of relatively immature sediments (green arkose and minor wackes with abundant rock fragments) and exhibits common tabular and trough cross-beds and graded beds. Current directions are from the north. Successively younger sediments are also immature with >20 to 25 percent feldspar grains and a large percentage of lithic fragments within the framework. Most of the lithologic and structural features would indicate a shallow marine rather than fluvial depositional environment for rocks of the Lorrain Formation within the map area. However, as stated by Rice (1986), any and all of the key sedimentological features such as bed forms, wave forms and the internal stacking arrangement could be found in either shallow marine or fluvial environments. Thus, the environment may represent an original fluvial deposit reworked in a shallow marine basin.

MAFIC INTRUSIVE ROCKS

Nipissing Diabase

Early Proterozoic Nipissing quartz diabase occurs as both sills and dikes within the map area. The most prominent diabase body is a north-trending, 300 m thick sill which dips 20° to the east and underlies the central part of the map area. A major 200 m wide, northeast-trending dike and several narrower (20 to 40 m wide), northwest-trending dikes are located in eastern Cassels and Riddell townships. Nipissing diabase are 2160 Ma (Van Schmus 1965) and mainly intrude sediments of the Coleman Member and to a lesser extent the rocks of the Firstbrook Member and of the Lorrain Formation.

Contact metamorphism of these sedimentary rocks has resulted in spotted chlorite and feldspar alteration in rocks of the Lorrain Formation and local chloritization, epidotization and recrystallization within rocks of the Coleman and Firstbrook members at several localities (as previously described).

Coarse-grained quartz diabase, varied textured diabase and minor leucocratic quartz gabbro and granophyre are the main lithologies within the differentiated sill.

The most common Nipissing rock is a massive, equigranular, medium- to coarse-grained, subophitic, quartz diabase. Dark-green coloured fresh surfaces and dark brown-green weathered surfaces are common. Fine-grained varieties do occur and are more common near the margins of the sill.

TABLE 9. CHEMICAL ANALYSES AND NORMATIVE MINERALS OF EARLY PROTEROZOIC NIPISSING DIABASE ROCKS, CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		28	29	30	31	32
Sample No.		0061*	5024	2003	4605	2407
Major Elements (wt%)						
SiO_2		51.90	51.60	51.60	52.50	60.20
Al_2O_3		15.60	14.00	13.70	19.40	12.70
Fe_2O_3		2.03	1.90	3.00	2.82	3.00
FeO		8.89	9.33	9.40	7.18	8.19
MgO		5.89	6.09	5.67	2.80	1.81
CaO		10.10	9.12	8.07	3.85	4.12
Na_2O		2.19	2.00	1.59	4.45	4.84
K_2O		0.46	0.74	1.28	2.20	0.68
TiO_2		0.69	1.00	1.20	1.03	1.10
P_2O_5		0.06	0.07	0.06	0.13	0.26
MnO		0.17	0.19	0.20	0.11	0.13
CO_2		0.19	0.40	0.26	0.20	0.18
S		0.04	0.12	0.06	0.02	0.22
H_2O^+		0.94	1.79	2.16	2.68	1.37
H_2O^-		0.09	0.06	0.16	0.05	00.00
LOI		0.20	1.50	2.20	2.20	0.90
Trace Elements (ppm)						
Ag	AA	<2	<2	<2	<2	<2
As	AA	3	4	4.5	4.5	14
Bi	AA	1.1	0.8	0.9	1	1.2
Co	AA	44	45	47	22	36
Cr	AA	28	33	22	235	14
Cu	AA	135	122	114	22	91
Ni	AA	72	73	60	58	10
Pb	AA	156	133	17	24	55
Zn	AA	80	92	105	102	710
Be	ICP/OES	2	3	3	3	2
Co	ICP/OES	40	15	50	25	35
Cu	ICP/OES	145	140	130	22	100
Mo	ICP/OES	<10	<10	<10	<10	<10
Ni	ICP/OES	85	90	75	75	18
Sc	ICP/OES	30	35	40	22	24
Sr	ICP/OES	205	205	230	435	95
V	ICP/OES	225	270	355	190	85
Y	ICP/OES	18	24	22	18	50
Zn	ICP/OES	80	95	105	100	740
Hg (ppb)	AA	<20	<20	<20	<20	160
Au "	AA	<2	<2	2	<2	9
Pt "	AA	<1	<1	1	2	<1
Pd "	AA	<1	<1	2	1	<1
Rock Type		varied textured diabase	diabase	varied textured diabase	diabase	varied textured diabase
approximate stratigraphic height above lower contact		90m	100m	120m	600m	780m

In thin section, typical subophitic textures are common with euhedral plagioclase and actinolite and hornblende replacing and rimming original pyroxenes. Interstitial quartz (10 to 15 percent), 5 to 10 percent biotite, epidote and minor titanite and magnetite are other mineral phases. Several unaltered samples contain 5 to 10 percent relict clinopyroxene (augite) with distinctive exsolution lamellae and normally zoned, euhedral, plagioclase (An_{40-58}). More commonly, the plagioclase has been altered to epidote and sericite and original compositions cannot be determined.

Varied textured diabase occurs towards the top of the sill and in the centre of the major (200 m wide) northeast-trending dike. Typically, it consists

TABLE 9. (Continued)

Reference No.	28	29	30	31	32
Sample No.	0061	5024	2003	4605	2407
CIPW Norms					
APTT	0.14	0.17	0.15	0.32	0.63
PYRT	0.00	0.00	0.00	0.00	0.00
ILMN	1.33	1.97	2.37	2.02	2.15
ORTH	2.77	4.53	7.88	13.45	4.13
ALBT	18.88	17.55	14.01	38.95	42.13
ACMT	0.00	0.00	0.00	0.00	0.00
ANRT	0.00	28.04	27.56	17.57	11.23
SPHN	3.00	0.00	0.00	0.00	0.00
RUTL	0.00	0.00	0.00	0.00	0.00
MGNT	7.91	2.86	4.53	4.23	4.47
HEMT	6.50	0.00	0.00	0.00	0.00
DIOP	0.00	7.16	5.47	0.00	1.87
HEDN	11.27	5.87	4.45	0.00	3.98
WOLL	10.63	0.00	0.00	0.00	0.00
ENST	5.17	12.41	12.17	7.21	3.77
FERS	0.00	11.67	11.35	9.68	9.18
QRTZ	0.00	6.84	9.46	2.51	16.03
FORS	0.00	0.00	0.00	0.00	0.00
FAYA	0.00	0.00	0.00	0.00	0.00
PVSK	0.00	0.00	0.00	0.00	0.00
NEPH	0.00	0.00	0.00	0.00	0.00
LEUC	0.00	0.00	0.00	0.00	0.00
DICA	0.00	0.00	0.00	0.00	0.00
KALP	0.00	0.00	0.00	0.00	0.00
CNDM	0.00	0.00	0.00	3.59	0.00
CALC	0.44	0.94	0.62	0.47	0.42
NPLG	62.87	61.50	66.30	31.09	21.05
FEMG	0.26	0.27	0.25	0.15	0.13
RMG	0.58	0.58	0.58	0.49	0.35
RFE	0.42	0.42	0.42	0.51	0.65
C.I.	40.65	41.93	40.34	23.15	25.43

of patches of coarse-grained gabbro which contain pegmatitic pods of quartz and feldspar interstitial to cumulate pyroxene crystals.

Petrographic studies reveal that the mineralogy in varied textured gabbro is similar to regular Nipissing diabase except for the presence of granophyre (Photo 22) and minor amounts of carbonate. Epidote and sericite are alteration products of plagioclose. Unaltered plagioclose compositions are in the range of An_{30-35}.

Granophyric, quartz monzonite rocks are uncommon and only present at the top of the sill. These occur adjacent to the southwest shoreline of Cassels Lake in Riddell Township. Several vertical granophyre dikes (10 to 20 cm wide) crosscut varied textured diabase rocks at the Plexman Property (4) (*see* Economic Geology section). Other narrow granophyre veinlets intrude Huronian sediments overlying the diabase sill and suggest that the granophyre probably formed during partial melting of overlying sediments by the host diabase sill.

Hand samples generally have light green-pink-coloured weathered and light grey-green-coloured fresh surfaces.

In thin section, typical mineral assemblages of the granophyre consist of plagioclase, microcline, epidote, quartz, granophyre (intergrown feldspar and quartz) and minor chlorite, biotite, titanite and magnetite.

Textures are mostly hypidiomorphic granular with minor mortar textures of euhedral to anhedral plagioclase, alkali feldspar and quartz with few mafic minerals.

Leucocratic quartz gabbro is a minor lithologic variation of the main diabase and occurs mainly south of Sauvé Lake in Cassels Township. Typically, this rock exhibits pink-coloured weathered surfaces and light grey-coloured fresh surfaces with 10 percent or less of amphiboles. Characteristically the rocks are quartz-rich, coarse grained, and massive in habit with subophitic to sugary, hypidiomorphic granular textures.

TABLE 9. (Continued)

Reference No.		33	34	35	36	37	38
Sample No.		2077	2088	2091	0554	0275	4213
Major Elements (wt%)							
SiO_2		49.40	57.30	54.30	50.30	51.80	59.20
Al_2O_3		11.00	14.30	12.90	15.20	15.70	11.30
Fe_2O_3		4.10	4.90	6.80	1.60	2.22	4.70
FeO		14.00	8.37	9.63	9.26	8.89	7.92
MgO		3.68	1.57	2.09	7.06	5.29	1.83
CaO		6.82	2.92	3.31	7.84	9.32	5.95
Na_2O		3.30	4.41	5.01	2.64	2.56	4.62
K_2O		1.03	1.86	0.86	0.68	0.89	0.41
TiO_2		2.19	0.95	2.02	0.75	0.89	0.93
P_2O_5		0.13	0.30	0.20	0.04	0.08	0.28
MnO		0.31	0.16	0.25	0.20	0.18	0.14
CO_2		0.10	0.70	0.20	0.43	0.26	0.69
S		0.15	0.02	0.05	0.07	0.05	0.04
H_2O^+		2.03	2.02	1.61	2.80	1.02	0.42
H_2O^-		0.19	0.15	0.12	0.05	0.10	0.06
LOI		1.60	1.90	1.30	2.90	1.30	1.10
Trace Elements (ppm)							
Ag	AA				<2		
As	AA				3.5		
Bi	AA				1.1		
Co	AA	54	21	34	45	46	27
Cr	AA	<10	92	<10	187	15	<10
Cu	AA	108	16	22	78	144	155
Ni	AA	9	18	<5	102	540	<5
Pb	AA	21	10	11	19	<10	<10
Zn	AA	165	128	132	131	98	70
Be	ICP/OES	4	2	2	3	2	1
Co	ICP/OES	45	14	30	40	35	20
Cu	ICP/OES	160	24	40	85	185	200
Mo	ICP/OES	<10	<10	<10	<10	<10	<10
Ni	ICP/OES	22	25	10	120	60	9
Sc	ICP/OES	55	30	45	30	40	35
Sr	ICP/OES	225	205	120	240	190	300
V	ICP/OES	360	65	65	230	205	70
Y	ICP/OES	30	40	45	14	17	65
Zn	ICP/OES	140	95	105	120	75	55
Hg (ppb)	AA				<20		
Au "	AA				<2		
Pt "	AA				26		
Pd "	AA				23		
Rock Type		varied textured diabase 40m	granophyre 680m	granophyre 700m	diabase 70m	diabase 460m	varied texture diabase 480m

Alteration of Nipissing diabase rocks occurs adjacent to quartz and carbonate veins related to minor copper, cobalt and silver mineralization (*see* Economic Geology section, properties 3 and 4). Commonly the samples consist of hydrothermally altered, coarse-grained, massive gabbro with approximately 50 percent amphiboles and some relict subophitic textures. Weathered surfaces are typically light brown coloured; fresh surfaces are grey. One example of such alteration is near the Gosselin occurrence, in a 1 m wide carbonate zone containing 10 to 20 percent quartz and chlorite clots adjacent to a 20 to 30 cm wide quartz vein with minor pyrite. Thin sections from this occurrence exhibit several generations of carbonate minerals, together with minor quartz and chlorite.

Other thin sections of hydrothermally altered and fractured diabase indicate mineral assemblages of 30 percent plagioclase (An_{28}), 20 percent hornblende, 10 percent biotite, 10 percent quartz, 10 percent microcline, 5 percent epidote, 5 percent

TABLE 9. (Continued)

Reference No.	33	34	35	36	37	38
Sample No.	2077	2088	2091	0554	0275	4213
CIPW Norms						
APTT	0.32	0.73	0.49	0.10	0.19	0.68
PYRT	0.00	0.00	0.00	0.00	0.00	0.00
ILMN	4.33	1.85	3.93	1.48	1.72	1.80
ORTH	6.34	11.25	5.21	4.19	5.36	2.47
ALBT	29.07	38.18	43.45	23.27	22.09	39.90
ACMT	0.00	0.00	0.00	0.00	0.00	0.00
ANRT	12.66	8.29	10.42	28.77	29.28	9.07
SPHN	0.00	0.00	0.00	0.00	0.00	0.00
RUTL	0.00	0.00	0.00	0.00	0.00	0.00
MGNT	6.19	7.27	10.10	2.42	3.28	6.96
HEMT	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	6.29	0.00	1.25	4.10	6.88	4.47
HEDN	11.54	0.00	1.93	3.01	6.08	8.03
WOLL	0.00	0.00	0.00	0.00	0.00	0.00
ENST	6.62	4.00	4.75	16.41	10.24	2.58
FERS	13.94	10.28	8.40	13.83	10.38	5.31
QRTZ	2.48	14.44	9.61	1.41	3.89	17.15
FORS	0.00	0.00	0.00	0.00	0.00	0.00
FAYA	0.00	0.00	0.00	0.00	0.00	0.00
PVSK	0.00	0.00	0.00	0.00	0.00	0.00
NEPH	0.00	0.00	0.00	0.00	0.00	0.00
LEUC	0.00	0.00	0.00	0.00	0.00	0.00
DICA	0.00	0.00	0.00	0.00	0.00	0.00
KALP	0.00	0.00	0.00	0.00	0.00	0.00
CNDM	0.00	2.11	0.00	0.00	0.00	0.00
CALC	0.24	1.63	0.47	1.02	0.60	1.60
NPLG	30.34	17.84	19.35	55.28	57.00	18.52
FEMG	0.25	0.12	0.12	0.30	0.24	0.12
RMG	0.38	0.34	0.43	0.61	0.56	0.39
RFE	0.62	0.66	0.57	0.39	0.44	0.61
C.I.	48.91	23.40	30.37	41.26	38.59	29.15

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-0061.*

sericite, 3 percent titanite, 3 percent hematite and 1 percent apatite. Textures are typically subophitic to blastophitic with hornblende and biotite replacing original pyroxenes and epidote and sericite replacing some of the original plagioclase.

Mineral assemblages of most Nipissing intrusive rocks generally reflect upper greenschist metamorphic conditions with diagnostic hornblende and/or actinolite and epidote as stable mineral assemblages. Only rarely do any of the Nipissing rocks reflect either unmetamorphosed or lower greenschist metamorphic conditions with original pyroxenes and actinolitic amphiboles, respectively.

Petrochemistry

Chemical analyses and norms of 11 representative samples are listed in Table 9. The reference numbers are arranged in ascending stratigraphic order with samples 28 to 35 from the thickest part of the sill (southern part in Riddell Township), and samples 36 to 38 from a narrower part of the sill (northern part in Cassels Township). Locations are given in Figure 3. These analyses are plotted in Figures 7 and 8 and illustrate major chemical differences between Nipissing diabase, Archean diabase dikes and Middle Proterozoic olivine diabase dikes.

The slightly differentiated nature of the Nipissing diabase sill is reflected by the fractionated compositions of normative plagioclase (Table 9). Compositions are more calcic near the base and become more sodic near the top of the sill.

Similar chemical variations of Nipissing diabase occur throughout the Southern Province and are well documented and characterized by Card and Pattison (1973).

MIDDLE PROTEROZOIC

Olivine Diabase Dikes (Sudbury Swarm)

The youngest Precambrian rocks in the area are represented by a northwest-trending, 200 m wide olivine diabase dike of the Sudbury Swarm which cuts across Cassels Township.

Card et al. (1973) suggest that the dike swarms occurred as a response to incipient continental rifting caused by convection in the mantle some 1220 Ma (Fahrig and West 1986).

In addition to the main dike, several parallel and narrower dikes occur. These narrow dikes, however, are traceable over only short distances.

The diabase is mainly coarse grained, with common ophitic textures. Minor dark brown-coloured, fine-grained, chilled rock types occur near the margins of the dikes, and also form the narrower parallel dikes.

In thin section, plagioclase, clinopyroxene (titanaugite), and olivine are the principal mineral phases together with minor biotite, apatite and magnetite. Ophitic textures are ubiquitous with plagioclase enclosing pyroxenes and olivines. Mineral assemblages reflect the unaltered and unmetamorphosed nature of the olivine diabase rocks.

Chemical analyses of representative samples (Sample Nos. 39 and 40) are presented in Table 10 and plotted in Figures 7 and 8.

PHANEROZOIC

CENOZOIC

Quaternary

PLEISTOCENE AND RECENT

Pleistocene deposits cover 70 to 80 percent of the map area and are typically glacial in origin. Ice di-

TABLE 10. CHEMICAL ANALYSES AND NORMATIVE MINERALS OF MIDDLE PROTEROZOIC OLIVINE DIABASE DIKES (SUDBURY SWARM) IN CASSELS AND RIDDELL TOWNSHIPS.

Reference No.		39	40
Sample No.		0191*	0209
Major Elements (wt%)			
SiO_2		42.30	43.50
Al_2O_3		13.00	15.90
Fe_2O_3		4.10	2.90
FeO		15.00	13.80
MgO		1.69	4.72
CaO		7.50	7.10
Na_2O		3.62	3.83
K_2O		1.36	1.14
TiO_2		4.65	3.89
P_2O_5		1.20	0.69
MnO		0.24	0.20
CO_2		0.20	0.15
S		0.03	0.10
H_2O^+		0.76	0.62
H_2O^-		0.18	0.11
LOI		0.40	0.30
Trace Elements (ppm)			
Co	AA	49	51
Cr	AA	23	26
Cu	AA	82	53
Ni	AA	39	53
Pb	AA	<10	10
Zn	AA	195	165
Be	ICP/OES	4	4
Co	ICP/OES	60	50
Cu	ICP/OES	–	80
Mo	ICP/OES	<10	<10
Ni	ICP/OES	55	62
Sc	ICP/OES	45	23
Sr	ICP/OES	450	555
V	ICP/OES	250	255
Y	ICP/OES	60	40
Zn	ICP/OES	195	165

Reference No.	39	40
Sample No.	0146	5042
CIPW Norms		
APTT	2.90	1.67
PYRT	0.00	0.00
ILMN	9.02	7.55
ORTH	8.21	6.89
ALBT	26.72	27.30
ACMT	0.00	0.00
ANRT	15.54	23.33
SPHN	0.00	0.00
RUTL	0.00	0.00
MGNT	6.07	4.30
HEMT	0.00	0.00
DIOP	4.88	2.64
HEDN	6.16	3.31
WOLL	0.00	0.00
ENST	0.00	0.00
FERS	0.00	0.00
QRTZ	0.00	0.00
FORS	6.78	7.56
FAYA	10.83	11.98
PVSK	0.00	0.00
NEPH	2.48	3.16
LEUC	0.00	0.00
DICA	0.00	0.00
KALP	0.00	0.00
CNDM	0.00	0.00
CALC	0.46	0.35
NPLG	33.49	41.74
FEMG	0.25	0.25
RMG	0.48	0.48
RFE	0.52	0.52
C.I.	43.75	37.34

**All sample numbers are abbreviated from the standard OGS sample numbers, e.g., 86PJB-0191.*

rections from the northeast are indicated by glacial striae which commonly strike 020°. Much of the area except swamps and lakes are covered by a thin cover of glacial till. Subsequent reworking of the till has resulted in several north-trending glaciofluvial, outwash plains (Roed 1979; Gartner 1980). These are located in low-lying areas near Sauvé and Watson lakes in Cassels Township and east of Upper Twin Lake in Riddell Township.

Recent deposits consist mainly of organic (swamp) and lake deposits. Several such low-lying swamp areas occur along the eastern margin of the map area, both northeast and southeast of Blueberry Lake in Cassels Township.

Structural Geology

REGIONAL SETTING

The map area includes parts of two structural provinces of the southern Canadian Shield: the Superior Structural Province which includes all Archean rocks; and the Southern Structural Province which consists of Early Proterozoic Huronian sedimentary and Nipissing intrusive rocks, and Middle Proterozoic dike rocks.

Deposition of Archean metavolcanics occurred on a basement of older sialic rocks, not recognized in the present area. Subsequent deformation, regional metamorphism and emplacement of granitic plutons occurred during the Kenoran Orogeny 2500 Ma or more (Stockwell et al. 1970)

This was followed by a period of tensional tectonics with emplacement of Archean mafic dikes.

Extensive block faulting of Archean rocks during tensional tectonics caused the formation of a series of crustal blocks, creating a horst and graben terrain. Subsequent deposition of Huronian rocks occurred in a series of cratonic sedimentary basins. Deformation and metamorphism occurred after the emplacement of Nipissing intrusive rocks some 2150 Ma. It probably occurred about 1900 Ma during the Penokean Orogeny (Van Schmus 1965). Further tensional tectonics resulted in the emplacement of the Sudbury Swarm dikes some 1220 Ma.

Some of the Huronian sedimentary rocks in the southern part of the map area also underwent a subsequent second deformation. This probably occurred during the Grenville Orogeny about 1000 Ma (Stockwell et al. 1970).

FOLDING

Archean metavolcanic rocks generally exhibit a well-developed foliation or penetrative cleavage subconcordant to primary features such as bedding in pyroclastic rocks. This is characterized by steeply dipping (subvertical) foliations which are oriented in a northeast direction.

Archean metavolcanic rocks in Cassels Township are folded in the shallow (20°) northeast-plunging Lake Tetapaga syncline (Bennett 1978; Fyon and Crockett 1986). To the south in Riddell Township, pillowed flows indicate top directions to the east and northeast. This orientation is the same as the nearest metavolcanic rocks some 5 km to the north on the southern flanks of the Lake Tetapaga syncline.

Sedimentary rocks of the Proterozoic Gowganda and Lorrain formations are variably schistose and commonly well bedded. The schistosity is defined by the planar alignment of platy metamorphic minerals such as chlorite and muscovite whereas bedding is defined by original grain-size and compositional differences. Commonly, the schistosity is parallel to bedding but more steeply inclined. In other cases, however, schistosity directions are clearly perpendicular to the bedding directions. This occurs particularly in the nose of several folds. Cleavage-bedding intersections and younging directions, also indicate several reversals in structural facing (Kehlenbeck 1984) within the southern half of the map area. Thus, the interpreted F_1 fold hinges are oriented in east-northeast and northeast directions. Elsewhere, northeast-trending (F_1) fold axes are parallel to the original bedding and are represented by a local north- and northeast-trending penetrative cleavage/schistosity. The net effect of F_1 folds was to steepen the attitudes of original beds in the east-facing synclinorium from horizontal to 10° to 45°. Numerous minor structures (drag folds), lineations and shear zones are also associated with the F_1 folding event. The structures gently plunge (0° to 20°) mainly to the northeast but also to the southwest. This would indicate a doubly plunging fold hinge which must have been warped as a result of a second folding event (F_2). Throughout most of the map area, effects of the F_2 folding event are evident as intermittent, northwest-trending vertical schistosities produced by northeast to southwest compressional forces. However, in the southern half of the map area it is represented by a series of bedding reversals outlining several northwest-trending anticlines and synclines between Snake Island Lake and Rabbit Point on Rabbit Lake. The dominant foliation trends in this area are northwest striking and steeply dipping (Figure 10) and represent the penetrative schistosity which is associated with the F_2 folding event. Bedding orientations are more variable (Figure 11) but mainly indicate northwest-striking and shallow, southwest-dipping strata. The resultant cleavage/bedding intersections indicate northwest, shallow-plunging (0° to 10°) F_2 fold hinges. The refolding resulted in a series of east- to southeast-trending anticlines and synclines in which strata dip 15° to 35° to the east or west. Throughout the rest of the map area a series of gentle basins and domes have been produced by the gentle warping of northeast-trending F_1 fold axes and lineations. However, the geometry of rock types within two northeast-trending anticlines confirms that shallow (0° to 20°) northeast-plunging fold hinges predominate over southwest-plunging structures. These structures are located east of Sauvé Lake and northeast of Rabbit Point. The general basin-like geometry is also reflected by regional bedding attitudes as shown in Figure 12 which illustrates the poles to bedding of all Huronian rocks in the map area.

It is believed that F_1 folding probably occurred during the Penokean Orogeny (1900 Ma) while F_2

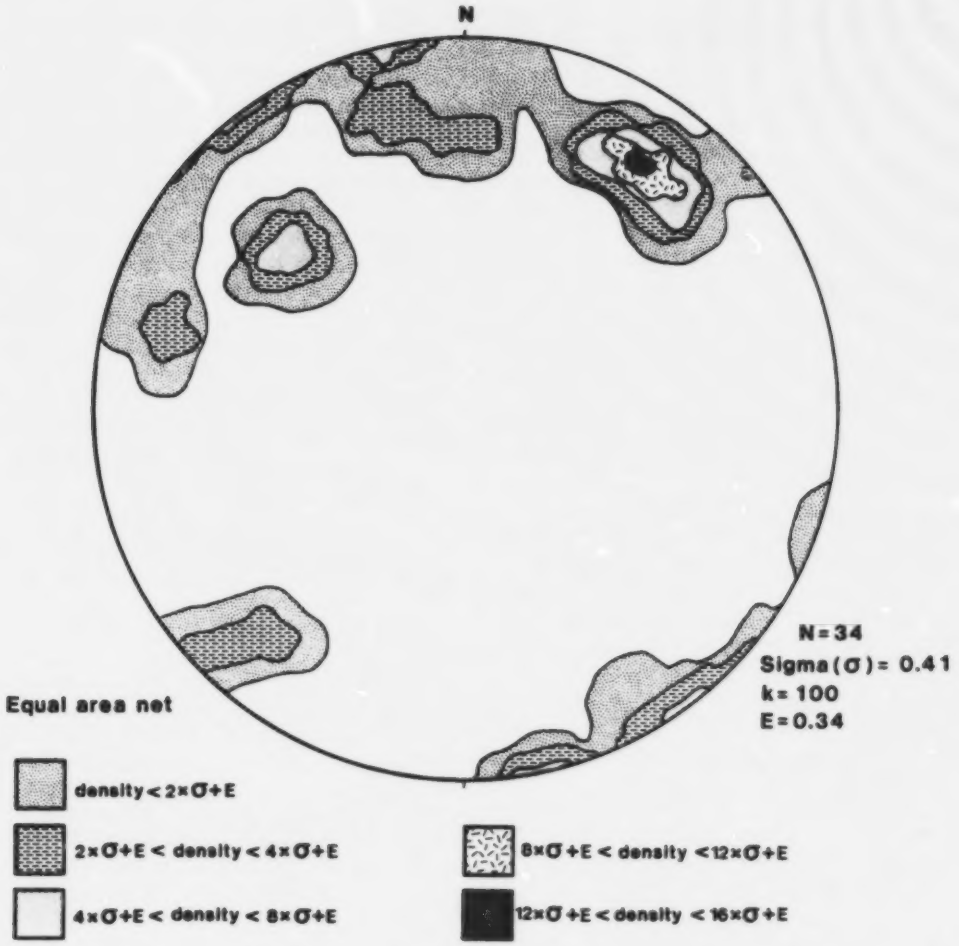

Figure 10. *Poles to foliation - Snake Island Lake to Rabbit Point area, Cassels and Riddell townships: lower hemisphere projection on an equal area net (Schmidt net).*

folding was possibly related to the later Grenville Orogeny (approximately 1000 Ma) since its effects are mainly seen in the part of the map area closest to the Grenville Front. The distance from the Front to the southern edge of the map area is approximately 6 km.

FAULTS, LINEAMENTS AND SHEAR ZONES

Throughout the map area several lineaments and shear zones/fault zones have been identified.

Many of the lineaments were interpreted from airphoto examination and most likely represent fractures or faults. These lineaments are not identified as faults due to a lack of field evidence. The lineaments strike in two prominent directions; a dominant northwest set and a lesser northeast set. Prominent joint sets in all rock types show a similar distribution. Northwest-trending dikes were emplaced along several of these lineaments. These include: a) Archean mafic dikes cutting Archean felsic plutonic rocks; b) Nipissing diabase dikes cutting sediments of the Lorrain Formation; and c) olivine diabase of the Sudbury Swarm intruding both Proterozoic sediments and Archean lithologies. Few Archean diabase dikes were emplaced along northeast-trending lineaments.

Northwest-trending lineaments are possibly related to fracturing associated with the development of the Lake Timiskaming rift system (Lovell and Caine 1970). Alternatively, the northwest and northeast sets may represent extensional fractures

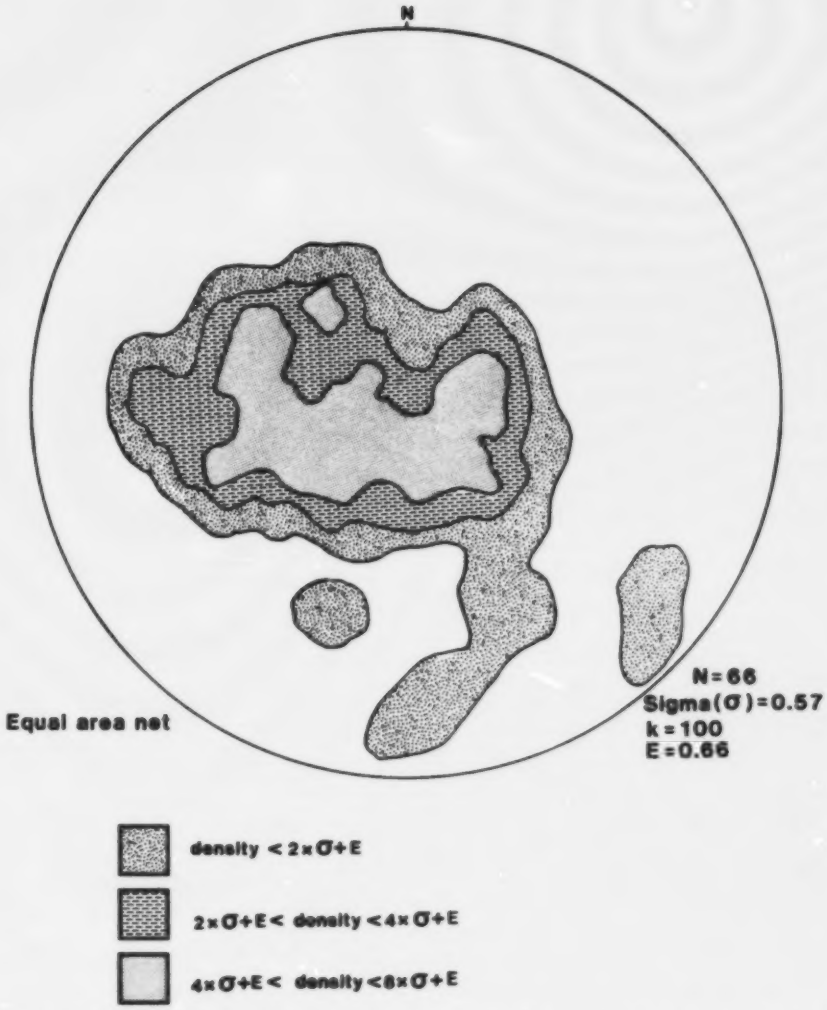

Figure 11. *Poles to bedding - Snake Island Lake to Rabbit Point area, Cassels and Riddell townships: lower hemisphere projection on an equal area net (Schmidt net).*

related to the F_2 and F_1 folding of Huronian strata, respectively.

The main shear zone within the map area is the northeast-trending Link Lake deformation zone which cuts the Archean metavolcanics of the Lake Tetapaga syncline in the Boot Bay (Net Lake) area of Cassels Township. The LLDZ is approximately 800 to 1000 m wide and contains sheared, flattened and deformed Archean metavolcanic rocks. The main structural evidence indicates deformation by pure shear with little or no rotational component, or any sinistral or dextral displacements.

Petrographic examinations of rocks within the shear zone indicate the presence of cataclastic and protocataclastic textures with features such as partly milled rock fragments, pressure shadows and some kink banding. These lithologies have also undergone concurrent and subsequent alteration and metasomatism with varying degrees of carbonatization, chloritization and possibly silicification. Minor sulphide mineralization is also associated with the deformation zone. Thus, the LLDZ could represent a zone for potential gold mineralization.

Several southeast-trending conductive zones beneath Outlet Bay (Net Lake) have been outlined by previous electromagnetic surveys (*see* Economic Geology section). These possibly represent later, southeast-trending and offsetting shear or fault zones cutting the LLDZ. There is little field evidence how-

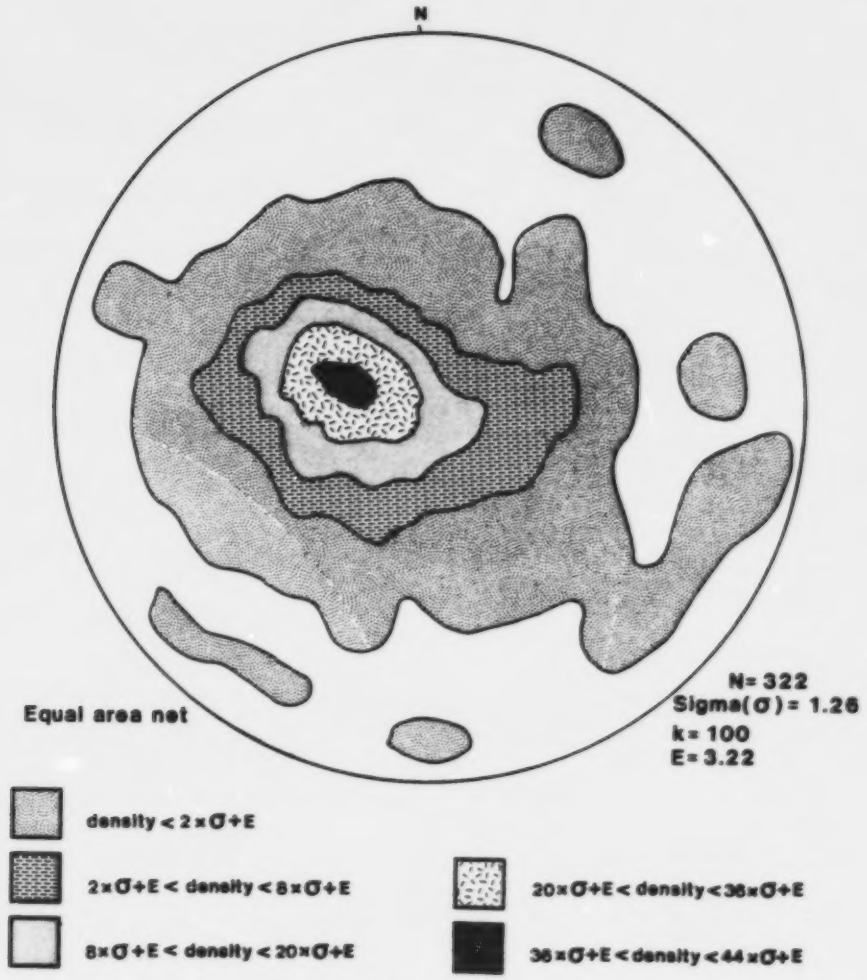

Figure 12. *Poles to bedding - entire map area, Cassels and Riddell townships: lower hemisphere projection on an equal area net (Schmidt net).*

ever, that major displacements have occurred along these faults.

In other areas, several northeast- and northwest-trending shear zones have been recognized within the younger Huronian strata. These shear zone directions coincide with the main northwest- and lesser, northeast-trending lineaments. This also suggests that the shear zones may be a result of compression and subsequent slip-strain related to northeast-trending F_1 folding and later, northwest-trending F_2 deformation.

At several locations on islands in Cassels Lake, extensive shearing and tectonic brecciation with subsequent rotation of tectonic clasts have been recognized. However, there is little field evidence that any major lithologic displacements have occurred along these shear zones. These zones are hosted within bedded siltstones of the Firstbrook Member of the Gowganda Formation.

Field and petrographic evidence for syndepositional faulting within sediments of the Gowganda Formation is indicated by several examples of soft-sediment deformation; mud draping and disruption; and bedding slumps and displacements.

Metamorphism

The grade of regional metamorphism within the map area varies from unmetamorphosed olivine diabase dikes of the Sudbury Swarm (Middle Proterozoic - 1220 Ma) to lower amphibolite facies (Winkler 1976) locally found in some Archean metavolcanics and Nipissing diabase rocks.

Archean mafic to intermediate metavolcanic rocks of the younger volcanic complex (YVC) consist of typical lower greenschist facies mineral assemblages of epidote+albite+chlorite+muscovite+calcite±actinolite. The occurrence of actinolite is part of an albite-epidote to hornblende hornfels contact aureole surrounding the Chambers–Strathy batholith (Brons 1987).

Widespread carbonatization, chloritization and sericitization indicative of a major metasomatism is evident within both mafic and felsic rocks of the YVC; particularly within the Link Lake deformation zone. This phenomena has been extensively studied in the Temagami greenstone belt in areas to the west of Cassels Township by Beswick and Soucie (1978) and Beswick and James (1984). By using molecular proportion diagrams of the type proposed by Pearce (1968), they have shown that Na_2O, K_2O and CaO have been extensively remobilized whereas SiO_2, Al_2O_3, TiO_2 and MgO are relatively immobile. Data from Cassels Township outline similar trends indicative of extensive Na_2O, K_2O and CaO metasomatism which probably coincided with regional metamorphism and deformation.

Amphibolite facies metamorphic rocks occur in the older volcanic complex (OVC) in Riddell Township. In higher-grade metamorphic rocks, the mafic metavolcanic rocks are increasingly recrystallized and foliated. The development of granoblastic textures is common. Plagioclase is recrystallized into equigranular, untwinned, subhedral grains. Chlorite, actinolite and clinozoisite are replaced by granoblastic hornblende and epidote. Typically, there is a total absence of muscovite/sericite and carbonate in the mafic metavolcanic rocks of the OVC.

Metamorphism was coincident with deformation of the rocks during the Kenoran Orogeny. It occurred prior to, or during the emplacement of the Archean felsic plutonic rocks some 2500 Ma.

Contact metamorphism of Archean mafic metavolcanic rocks and sedimentary rocks of the Proterozoic Gowganda and Lorrain formations occurred during the emplacement of Nipissing intrusive rocks (2150 Ma). This resulted in albite-chlorite-epidote hornfels in mafic metavolcanic rocks south of Sauvé Lake. Chlorite-spotting and alkali feldspar clots have developed locally within arkoses of the Lorrain Formation adjacent to a dike located on Sunrise Lake. At several other locations, chloritization, epidotization and granoblastic recrystallization have occurred within sediments of the Coleman and Firstbrook members of the Gowganda Formation. Elsewhere, the sedimentary rocks exhibit typical lower greenschist facies, regional metamorphic mineral assemblages containing chlorite and muscovite and/or pyrophyllite.

The grade of metamorphism of Nipissing diabase varies from upper greenschist facies to relatively unaltered rocks containing some original, relict clinopyroxenes and unaltered plagioclase.

The upper greenschist facies rocks typically contain blue-green hornblende+biotite±actinolite whereas lower greenschist facies rocks commonly contain actinolite+biotite. Alteration of plagioclase has resulted in epidote or clinozoisite with minor muscovite in some amphibolite and lower-grade mineral assemblages.

Minor, subsequent, hydrothermal alteration of Nipissing diabase rocks occurred locally adjacent to quartz and carbonate veins related to minor copper, cobalt and silver mineralization (*see* Economic Geology, properties 3 and 4).

Metamorphism of Early Proterozoic sediments and Nipissing diabase (2150 Ma) probably occurred during the Penokean Orogeny some 1900 Ma (Van Schmus 1976).

Correlation of Aeromagnetic and Gravity Surveys with Geological Data

Cassels and Riddell townships are covered by GSC Geophysical Series maps 1490G (Ingall Lake) and 1491G (Temagami) (GSC 1965a, 1965b) published at a scale of 1 inch to 1 mile (1:63 360).

The most obvious anomalies are represented by several northwest-striking magnetic trends which cut across the northern part of Riddell Township and the central part of Cassels Township. These 1000 m wide zones correspond to a pair of Middle Precambrian olivine diabase dikes (Sudbury Swarm) and are characterized by a higher magnetic susceptibility and steep magnetic gradients with closely spaced, northwest-trending isomagnetic contour lines.

Areas underlain by Early Proterozoic rocks exhibit subcircular-shaped anomalies with fairly low magnetic values and flat magnetic gradients. Isomagnetic lines generally trend in a west to northwest direction.

These rock types include sedimentary rocks of the Gowganda and Lorrain formations and most Nipissing diabase rocks. The thickest part of the Nipissing diabase sill in Riddell Township is, however, characterized by several subcircular, negative magnetic anomalies which trend in an easterly direction parallel to its upper contact. Elsewhere, the relatively thin diabase sill does not appear to have a distinctive magnetic signature.

Another area of high magnetic values and fairly steep gradients is located west of Cassels Lake in Cassels Township. This northeast-trending zone is underlain by Archean metavolcanic rocks that are part of the northeast extension of the Temagami greenstone belt. Nearby Archean felsic plutonic rocks however, are characterized by lower magnetic values and flatter magnetic gradients. The geophysical expression of the Link Lake deformation zone is characterized by a slightly negative, northeast-trending, magnetic anomaly with relatively flat magnetic gradients.

Regional gravity surveys are portrayed on Ontario Geological Survey maps P.2296 and P.2297 (Gupta and Wadge 1980a, 1980b). The main feature within the map area is a circular, gravity-high anomaly in the vicinity of Upper Twin and Lower Twin lakes in Riddell Township. Underlying this anomaly is the thickest part of the Nipissing diabase sill. The data may indicate the presence of a large Nipissing gabbro body at depth which would represent a feeder to diabase sills and dikes at surface.

Economic Geology

HISTORY OF MINERAL EXPLORATION

Mineral exploration for silver and cobalt in Cassels Township dates from 1900 with shaft sinking and trenching by Temagami-Lorraine Mining Limited in the Sauvé Lake area and Temagami-Cobalt Mining Co. Ltd. in the Gosselin Lake area. During this period a smaltite-bearing vein known as the Upper Twin Lake occurrence was discovered along the Ontario Northland Railway in Riddell Township.

Base metal exploration by Hermes Mines Limited in 1945 was centred on the Boot Bay and Outlet Bay areas of Net Lake in Cassels Township. This work consisted of 10 diamond-drill holes (801 m) at three locations.

Exploration for silver and cobalt near Gosselin Lake by E. de Camp in 1954 resulted in trenching and follow-up drilling of five holes for a total length of 365 m.

Base metal exploration during the 1950s consisted of several diamond-drill programs on known sulphide occurrences in Cassels Township. Five holes (178 m) were drilled by A. Brochu in 1955 on the Hermes copper occurrence just east of Outlet Bay, and six holes for a total of 151 m were put down by B. Riopel in 1955 on an occurrence on a peninsula of Cassels Lake.

Ground geophysical surveys and drilling (1 hole - 183 m) were carried out by Geoscientific Prospectors Limited in 1956 adjacent to Obashkong Lake. Twenty trenches and 11 drill holes for a total of 957 m were put down by New Athona Mines Limited in an area northeast of Outlet Bay. A ground geophysical survey was carried out in 1962.

The Gosselin silver-copper property near Gosselin Lake was extensively explored by Aldage Mines Limited in 1963. The work consisted of geological and geophysical surveys, prospecting, trenching and sampling and subsequent diamond drilling of 10 holes for a total of 331 m.

Soil geochemical and geophysical surveys on several claims adjacent to the Gosselin property were completed in 1964 by D. Burton.

Other work in 1964 consisted of three diamond-drill holes (107 m) by E. Burke on a galena showing at Boulton Lake in Riddell Township.

Airborne geophysical surveys were carried out by Keevil Mining Group in 1965 over the western half of Cassels Township. Later, follow-up geophysical surveys and diamond drilling were carried out by Wabi Mining Syndicate in 1968 on the former New Athona property, northeast of Outlet Bay. The following year, Rio Tinto Canadian Exploration Limited carried out geological and geophysical surveys and diamond drilling (five holes totalling 605 m) on the same property. Elsewhere in the area, a soil geochemical survey and diamond drilling of nine holes (554 m) were completed in 1969 by Silver Leader Mines Limited on a property to the east of Bogie Lake. Ground geophysical surveys by I. Schubert in the southwestern corner of Riddell Township, and by Lake Beaverhouse Mines Limited in the Boot Bay area of Cassels Township were completed between 1970 and 1971.

Geological surveys, trenching and three diamond-drill holes (705 m) were completed by Goldex Mines Limited in 1973 near a chalcopyrite showing along the Gowganda Formation-Nipissing diabase contact at Boulton Lake in Riddell Township.

Elsewhere in Riddell Township several trenches were put down during 1974 in Archean mafic metavolcanic rocks west of Lower Twin Lake by G. Vaillancourt.

Geological mapping by Canadian Nickel Company Limited in 1974 and ground geophysical surveys by Hollinger Mines Limited and St. Joseph Exploration Limited in 1978 were carried out northeast of Outlet Bay in Cassels Township.

Numerous leased and unpatented claims are in good standing at the time of the current survey (1986). No claim staking, however, has taken place since 1978 when both townships were withdrawn from staking. An alphabetical list of assessment work reported is shown in Table 11. These assessment work reports are on file at the Assessment Files Research Office, Ontario Geological Survey, Toronto, and duplicate copies are stored in the Resident Geologist's office, Cobalt, Ontario.

Occurrences of copper, cobalt, silver, gold, zinc, lead and nickel are known in Cassels and Riddell townships. These metals are found in polymetallic occurrences hosted in three main geological environments which are conveniently referred to as groups 1, 2 and 3. Of these groups, 1 and 2 represent Proterozoic mineralization and have a close spatial and genetic relationship. Group 3 represents earlier Archean mineralization. Descriptions of the groups are as follows:

1. Cu, Co, Ag $\pm$ Au, Ni and potential platinum group element (PGE) mineralization is hosted within the margins of the Proterozoic Nipissing diabase sill.
2. Cu, Ag and Pb mineralization is hosted within sedimentary rocks of the lowest part of the Proterozoic Coleman Member (Gowganda Formation) adjacent to the Nipissing diabase sill.
3. Cu and Zn mineralization is hosted within Archean felsic volcanic rocks in the form of volcanogenic massive sulphides.

TABLE 11. SUMMARY OF ASSESSMENT WORK (also listed in GDIFs 117 and 166) LOCATED IN THE ASSESSMENT FILE RESEARCH OFFICE AND RESIDENT GEOLOGIST'S OFFICE, COBALT.

	Company	Commodity	Date	Type of Work	Mineralization	Assays	Description
1)	Aldage Mines Limited	Ag,Co	1963, 1964	Geological mapping, geophysical survey, diamond drilling, trenching, stripping	cpy, py	R	quartz-calcite veins hosted in Nipissing diabase sill
2)	A. Brochu	base metals	1955	diamond drilling	cpy, gn	NR	quartz-calcite veins
3)	E. Burke	Ag,Co	1964	diamond drilling	gn,cpy	NR	quartz-calcite veins hosted in Nipissing diabase sill and sediments of the Gowganda Formation (Coleman Member)
4)	D. Burton	Ag,Co	1964	geological mapping, geochemical surveys, geophysical surveys	py		area has potential cobalt- and copper-bearing quartz carbonate veins hosted in Nipissing diabase
5)	Canadian Nickel Company Limited	base metals	1974	geological surveys	cpy,sph,py	NR	geological report
6)	E.de Camp	Ag,Co	1954	diamond drilling, stripping and trenching	cpy,cob,nc	NR	calcite veins hosted in Nipissing diabase
7)	Geoscientific Prospectors Ltd.	Ag,Co	1957	diamond drilling			cpy in calcite vein in wackes of the Coleman Member
8)	Goldex Mines Ltd.	Ag,Co	1973	diamond drilling, trenching stripping and geological survey	cpy	NR	cpy and py in calcite breccia ? hosted in wacke of the Coleman Member
9)	Hermes Mines Ltd.	base metals	1945	diamond drilling, trenching	cpy,sph,py	NR	sulphide hosted in archean felsic metavolcanics
10)	Hollinger Mines Ltd.	base metals	1978	ground electromagnetic survey	-	-	surveys outlined several conductors in Archean felsic volcanics
11)	Keevil Mining Ltd.	base metals	1965	airborne electromagnetic and magnetic survey	-	-	several magnetic anomalies were outlined but no electromagnetic conductors in area of Archean metavolcanics
12)	Lake Beaverhouse Mines Ltd.	base metals	1971	ground electromagnetic survey	-	-	several conductors were outlined within Archean metavolcanics
13)	Mining Geophysical Company Ltd.	base metals	1956	ground resistivity surveys	-	-	outlined various anomalies hosted in Archean metavolcanics
14)	New Athona Mines Ltd.	base metals	1956	ground electromagnetic survey, diamond drilling, stripping and trenching	cpy,sph, py	R	minor copper and zinc mineralization hosted in Archean felsic metavolcanics
15)	B. Riopel	Ag,Co	1956	diamond drilling, trenching	cpy,py,po	NR	minor sulphides hosted in Nipissing diabase sill
16)	Rio Tinto Canadian Exploration Ltd.	base metals	1969	diamond drilling, geological survey, ground electromagnetic and magnetic surveys	cpy,sph,py po	R	minor copper and zinc mineralization hosted in Archean metavolcanics
17)	I. Schubert	base metals	1970	geological survey, ground electromagnetic and magnetometer surveys, stripping and trenching	cpy,po,gn bn,sph	NR	minor sulphides hosted in Archean metavolcanics in Riddell Township
18)	Silver Leader Mines Limited	Ag,Co	1969	geochemical soil survey, diamond drilling	gn,sph,cpy	R	minor sulphidic in Archean metavolcanics and in wacke of the Coleman Member
19)	St. Joseph Exploration Limited	base metals	1978	ground electromagnetic survey	-	-	-
20)	Temagami-Lorraine Mining Company Ltd.	Ag,Co	1912	trenching, stripping and shaft sinking	ery,sm,cob	NR	shaft on a 10 cm wide quartz carbonate vein hosted in Nipissing diabase sill
21)	Temagami Mining Ltd.	base metals	1956	ground resistivity and self-potential surveys	-	-	several anomalies outlined in Archean metavolcanics
22)	D. Valliancourt	base metals	1974	trenching	-	-	trenching on minor sulphides hosted in Archean metavolcanics in Riddell Township
23)	Wabi River Mining Company Ltd.	base metals	1968	diamond drilling, ground electromagnetic and magnetometric surveys	po,py,cpy sph	R	minor sulphides hosted in Archean felsic metavolcanic
24)	Westville Mines Ltd.	base metals	1956	ground resisting and self-potential surveys	-	-	several anomalies were outlined in Archean metavolcanics

Abbrevations: Ag-silver; Co-cobalt; py-pyrite; po-pyrrhotite; gn-galena; sph-sphalerite; cpy-chalcopyrite; ery-erythrite; cob-cobaltite; sm-smaltite; bn-bornite; nc-nicolite; R-reported - see text for property description; NR-not reported

Group 1: Cu, Co, Ag ± Au and Ni mineralization is generally related to the upper margin of the Nipissing diabase sill in contact with sedimentary rocks of the Coleman Member of the Gowganda Formation. Generally, the mineralization occurs in narrow (10 to 30 cm) quartz-carbonate veins containing erythrite (cobalt bloom), chalcopyrite, pyrite, arsenopyrite ± smaltite, cobaltite, nicolite, galena and annabergite. Gold is generally a trace element but can occur in concentrations of up to 1 oz per ton. Such high concentrations may be related to tellurides associated with the copper, cobalt and silver mineralization.

Elsewhere, disseminated sulphides occur near the margins of the diabase sill and are mainly of interest for potential PGE (platinum group element) mineralization.

Group 2: Scattered disseminated sulphides are also locally present within the lowest part of the sedimentary rocks of the Coleman Member as minor pyrite, chalcopyrite and galena or in calcite-quartz veins containing these minerals. This occurs particularly along the diabase contact and/or above Archean felsic volcanic rocks which commonly contain disseminated sulphides. Minor copper, silver and lead mineralization is associated with these types of occurrences.

Group 3: Volcanogenic massive sulphide mineralization consisting of pyrite, pyrrhotite and minor chalcopyrite and sphalerite typically occurs as sulphide veins in hydrothermally altered Archean felsic volcanic flows and/or pyroclastic rocks. They possibly represent stringer zones associated with sulphide deposits that are not exposed or have been eroded. Both copper and zinc mineralization is associated with these types of occurrences.

On the following pages, a detailed description of the metal occurrences and their history of exploration activity are presented. They are listed, as previously discussed into three groups:

Group 1: polymetallic occurrences with Cu, Co, Ag ± Au, Ni and potential PGE mineralization

Group 2: polymetallic occurrences with Cu, Ag and Pb mineralization

Group 3: polymetallic occurrences with Cu and Zn mineralization.

The descriptions also conform to the following criteria.

1. In the case of claims held as of December 31, 1986, properties are listed in the name of the registered claim holder.
2. In the case of a known mineral deposit not included in (1), the property is identified by a geographic name, or a historically well-established name for that deposit.
3. In the case of ground on which there has been appreciable exploration activity but was not held as of December 31, 1986 and in which no notable mineral occurrences have been found, the properties are listed under the name of the last company or individual to work that area. In this case the name will be followed by a date in square brackets representing the year in which that work was done.

The number in round brackets following the property name is the property location number which is shown on the accompanying geological map (Map 2526).

The descriptions, if not otherwise stated, are based on data obtained from assessment file reports (Assessment File Research Office, Ontario Geological Survey, Toronto, and files of the resident geologist, Cobalt) or from field investigations undertaken by the author during the 1986 field season.

GROUP 1: OCCURRENCES HOSTED IN THE MARGINS OF THE NIPISSING DIABASE SILL

Four occurrences of this type are located in the map area. The main occurrences are the Plexman property (3) (Gosselin occurrence) and the Quebec Cobalt and Exploration Limited property (4) (Temagami–Lorraine occurrence). Minor occurrences are the Riopel occurrence (12) and Upper Twin Lake occurrence (14). All of these are located in Cassels Township except the Upper Twin Lake occurrence which is in Riddell Township.

Plexman, E., Property (Gosselin Occurrence) (3)

This property is located in the central part of Cassels Township in the Gosselin Bay area of Cassels Lake and consists of six (6) contiguous claims S471342 to S471347 inclusive.

HISTORY OF EXPLORATION

The earliest known exploration on the property was done by Temagami–Lorraine Mining Company Limited and Temagami-Cobalt Mining Company Limited prior to 1912. This consisted of stripping, trenching and 53 m (175 feet) of shaft sinking (Figure 13). A comprehensive description of work prior to 1925 and the geology of the occurrence is given by Todd (1925) as follows:

> On the southwest shore of Gosselin Lake a shaft, following a quartz-calcite vein, is down 175 feet (53 m) in Nipissing diabase. The vein is vertical for 110 feet (39 m) from the surface, and below this point it dips 55°W. A vein striking N55°W enters the shaft at the top. This vein which may be traced on the surface for 100 feet (31 m) west of the shaft varies in width from one to four inches (2 to 10 cm) and carries cobalt and nickel bloom with low values in silver. In the shaft near the surface, a two-foot (60 cm) calcite vein comes in which strikes north and south. This vein is mineralized with liberal amounts of chalcopyrite and pyrite but contains no cobalt minerals; it persists to the bottom of the shaft. The diabase contact with Cobalt conglomerate lies about 300 feet (91 m) to the southeast of the shaft, and from an exposure

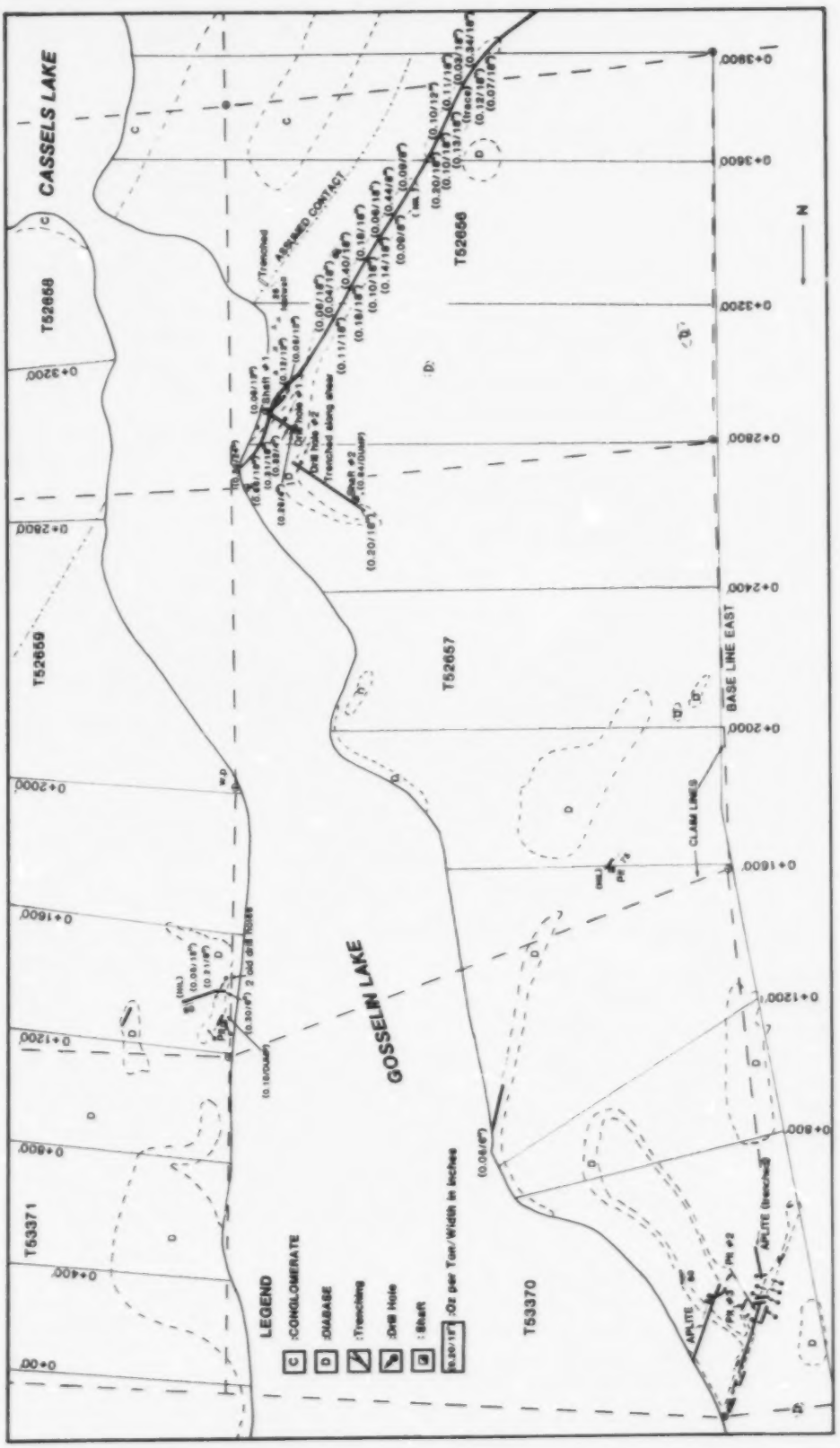

Figure 13. *Geology of the Plexman Property (Gosselin occurrence)(3). Map modified from information found in the Assessment Files Research Office, Ontario Geological Survey, Toronto.*

found in a trench across the contact, the conglomerate appears to dip under the diabase towards the shaft.

On the same claim, a short distance to the northwest, there is another shaft on a narrow vein carrying cobalt and nickel minerals. This vein runs parallel to the one at the surface of the other shaft, and in the vicinity the diabase is penetrated by a number of narrow aplite dikes also extending in the same direction.

The next period of exploration work on the property was carried out by E. de Camp in 1954. This consisted of stripping, trenching and follow-up diamond drilling on several mineralized veins 500 m north of the Gosselin shaft on the opposite shore (east side) of the lake. A five hole, 356 m (1169 feet) diamond-drill program was carried out to investigate the mineralized veins beneath and around a 4 m (12 feet) pit. Results of the program indicated the only lithology encountered around the pit was diabase with common calcite stringers at depths below 30 m (100 feet). Individual stringer veins (1 cm and less) contain minor amounts of either chalcopyrite, cobaltite or nicolite.

Subsequently, extensive exploration was carried out over 22 contiguous claims covering the Gosselin property by Aldage Mines Limited during 1963. The work consisted of electromagnetic and geological surveys (1:2400 scale), prospecting, trenching and sampling and subsequent diamond drilling of 10 holes for a total of 331 m.

Results from the electromagnetic survey were generally negative and failed to locate any conductive zones.

Prospecting and mapping however, resulted in the discovery of 21 quartz and quartz carbonate veins, three shear zones and one fracture zone. Results from 92 assays substantiated that only low values of silver occur on the property. Veins and shear zones generally strike in a north to northwest direction and are commonly vertical. They are characteristically narrow (1 to 80 cm) and traceable only over short distances.

Diamond drilling in the vicinity of the Gosselin shaft indicated little mineralization. Of the two holes drilled, only hole No.1 intersected a minor 40 cm (16 inches) wide quartz-carbonate vein at a vertical depth of 16 m (53 feet). Assay results indicated 0.11 ounce per ton Ag over 40 cm (16 inches). Prospecting near the northwest corner of Gosselin Bay yielded more positive results. Two 60 m long shear zones were located and contained a four-inch (10 cm) wide quartz-carbonate vein with massive chalcopyrite and minor erythrite. Several 30 to 50 cm wide aplite dikes cut the Nipissing diabase in the vicinity of the showings. Assay values reportedly averaged 4.52 ounces per ton Ag and 20% Cu (with maximum values of 5.90 ounces per ton Ag and 21% Cu) over a width of 10 cm and a length of 60 m (*see* Figure 13). Results from a series of eight short drill holes beneath the vein indicated average assay values of 0.57 ounce per ton Ag and 10.10% Cu (with maximum values of 2.28 ounces per ton Ag and 21.35% Cu) over a width of 40 cm. Apparently the drill intersections indicated that the mineralization decreased with depth and therefore no further work was recommended.

The last work done on the property was the drilling completed in 1964. Subsequently, the claims lapsed and were restarted by E. Plexman in August 1977.

GEOLOGY

Most of the Plexman property is underlain by massive Nipissing quartz diabase in contact with pebbly wackes of the Coleman Member to the north and south of the property (*see* Figure 13). Host rocks for the quartz-carbonate veins are local patches of varied textured Nipissing diabase which are sheared and extensively altered by hydrothermal solutions. The Gosselin shaft (53 m deep) near Gosselin Lake, was sunk on several northeast-trending 40 cm wide calcite-quartz veins. Sulphides present are chalcopyrite and pyrite containing 1 to 11% Cu, 3 ounces per ton Ag and 100 to 3400 ppm Co (Geoscience Laboratories, OGS, Toronto). A parallel and similar vein on the east side of Gosselin Lake is 20 cm wide and contains cobaltite or smaltite, erythrite, nicolite and annabergite (nickel bloom). Assays indicated 960 ppb Au, with 5950 ppm Co (Sample No. 33 - Table 12, Geoscience Laboratories, OGS, Toronto).

Another northeast-trending, 5 cm wide sulphide vein (800 m north of the shaft) contains chalcopyrite, pyrite and minor calcite. This vein is along a joint surface in relatively unsheared and unaltered varied textured diabase close to several crosscutting, aplitic, granophyre veins. Assay values indicated an average grade of 2.67 ounces per ton Ag and 15.76% Cu over a width of 10 cm for a length of 18 m (Assessment Files, Resident Geologist's office, Cobalt). Selected grab samples taken by the author indicated values of 2.75 ounces per ton Ag and up to 23.4% Cu (Sample Nos. 30 to 32 - Table 12).

Quebec Cobalt and Exploration Limited Property (Temagami-Lorraine Occurrence) (4)

This property consists of two contiguous leased claims TRT5658 and TRT5659 near Sauvé Lake in central Cassels Township. The only known work on the property consisted of trenching, stripping and shaft sinking (35 m) by the Temagami-Lorraine Mining Company Limited prior to 1912.

Todd (1925) visited the property and described it as follows:

An old shaft is down on a fracture in the diabase which runs about S 20°E. From material seen in the dump, the maximum width of the vein filling is about four inches (10 cm). Some samples from the dump show considerable cobalt bloom present, and one of the richest had an analysis of cobalt 5.87%, nickel 0.12%, copper 1.08%, iron 12.48%, sulphur 14.17%, arsenic 10.39%, and gold $22.40 (1.08 oz Au/ton), silver-trace (*see* Table 13).

TABLE 12. GRAB SAMPLE ASSAY VALUES FOR SAMPLES COLLECTED DURING THE 1986 FIELD SEASON. SAMPLE NUMBERS CORRESPOND TO LOCATION NUMBERS ON MAP FACE.
Values in ppb or ppm or if in brackets in percentage or oz/ton.

Sample No.	Au ppb	Ag ppm	Cu ppm	Co ppm	Pt ppb	Pd ppb	Ni ppm	As ppm	Hg ppb	Pb %	Mo ppm
1	2	<2	168	-	<1	<1	-	-	-	-	-
2	<2	<2	<1	-	-	-	-	-	-	-	-
3	55	<2	4320	-	-	-	-	-	-	-	-
4a	2	<2	115	30	<1	<1					
4b	11	<2	124	40	<1	<1					
4c	2	<2	28	20	<1	<1					
5	2	<2	56	-	-	-					
6	4	<2	5	-	-	-					
7	<2	<2	12	-							
8	<2	<2	103	-							
9	<2	<2	-	<5							
10	36.9 (ppm) (1.07 oz/ton)	20	3050	(2.14%)	<1	<1					
11	7	<2	1.34%	6							
12	<2	<2	-	7							
12b	2	<2	-	<5							
13	<2	<2	20	50							
14	12	<2	54	10							
15	22	<2	660	142							
16	9	<2	365	38							
17	4	<2	1040	160							
18	15	>2	188	420							
19	3	<2	630	97							
20	16	<2	-	-							
21	225	2	373	92							
22	5	>2	389	18							
23	<2	<2	39	14							
24	26	<2									
25	8	<2	650	90							
26	33	19	6000	52							
27	85	3	1750	25							
28	11	<2	1400	24							
29	7	<2	44	25							
30	<2	<2	8000	-							
31	<2	4	5720	-							
32	3	88	(23.4%)								
33	960	4	5720	-			3000				
34	<2	<2	-	-	4	2					
35	<2	<2	-	-	4	2					
36	<2	<2	-	<5							
37	<2	<2	12	<5							
38	18	45	-	<5							7.28%
39a	<2	<2	-	<5							
39b	<2	<2	-	14							
40	<2	<2									
41a	1195	<2	475	392							
41b	50	2	2090	5							
42	305	8<	(11.7%)	630							
43	1430	99	(2.04%)	3440							
44	26	<2	12	5							
45	3	<2									
46a	<2	<2	39	44	<1	<1					
46b	<2	<2	69	28	<1	<1					
47	6	<2	3940	14	<1	<1					
48	<2	<2	1520	20	<1	<1					
49	20	<2	-	11							

TABLE 12. (Continued)

Sample No.	Au ppb	Ag ppm	Cu ppm	Co ppm	Pt ppb	Pd ppb	Ni ppm	As ppm	Hg ppb	Pb %	Mo ppm
50	140	-	37	-							
51	<2	<2									
52	<2	<2	-	<5							
53	<2	<2	-	<5							
54	10	<2	14	<5							
55	-	-	-	-	-	-				<3	
56	<2	<2	64	8							
57	>2	<2	-	10							
58	2	<2	12	10							
59	2	<2	-	-	<1	<1					
60	<2	<2	-	-	<1	<1					
61a	<2	<2			<1	<1					
61b	<2	<2	-	24	-	-					
62	<2	<2	51	16	2	1					
63	3	<2	25	16	1	<1					
64	18	<2	530	-	12	7					
65	<2	<2	-	7							
66	<2	<2	-	36	7	6					
67	2	<2	-	<5				1.5			
68	6	<2	-	34	50	30					
69	6	<2		46	>1	<1					
70	2	<2		44	>1	<1					
71	<2	<2	-	-	<1	<1					
72	20	<2	(1.35%)	-	<1	<1					
73	<2	<2	58	20							
74	4	<2	-	44							
75	3	<2	-	44	2	1					
76	4	<2	-	40	1	<1					
77	28	<2	-	-	-	-					
78a	<2	<2	400	48							
78b	<2	<2	-	<5							
79	5	<2	-	40	1	<1		1			
80	<2	<2	5	<5	<1	<1					
81	<2	<2	9	<5	<1	<1					

A polished section of this material showed cobaltite, arsenopyrite, pyrite and chalcopyrite. The gold is not visible under the microscope.

GEOLOGY

The Temagami–Lorraine occurrence is hosted by varied textured Nipissing diabase which has undergone extensive local alteration by hydrothermal solutions adjacent to the veins. Adjacent and 150 m to the south of the shaft are Archean felsic volcanic rocks. The influence of the felsic volcanic rocks on the location and type of mineralization is uncertain.

The vertical 10 cm wide, southwest-trending calcite-quartz vein contains cobaltite, erythrite (cobalt bloom), arsenopyrite, pyrite and chalcopyrite. Samples taken by the author indicated values of 1.07 ounce per ton Au, 20 ppm Ag, 3050 ppm Cu and 2.14% Co (Sample No. 10 - Table 12).

The absence of visible gold probably suggests that the gold mineralization occurs with tellurides associated with arsenic-bearing sulphide minerals.

Upper Twin Lake Occurrence (14)

This occurrence is located on an abandoned railway siding near Upper Twin Lake in Riddell Township.

The occurrence was discovered when a cutoff was made in the Timiskaming and Northern Ontario railway prior to 1912. Todd (1925) visited the showing and described it as a small, narrow smaltite vein within the diabase.

GEOLOGY

The showing is hosted in the outer margins of the Nipissing diabase sill, just north of a contact with pebbly wackes and conglomerates of the Coleman Member of the Gowganda Formation. Minor pyrite, arsenopyrite and smaltite are contained in a 10 cm wide calcite-quartz vein. The vein strikes in a southeast direction and is traceable for a distance of 2 to 3 m.

Values from samples taken (Sample No. 68 - Table 12) indicate low silver and copper values with 50 ppb Pt and 30 ppb Pd (Geoscience Laboratories, Toronto). Although these values are not of eco-

TABLE 13. FOLLOWING ARE FROM THE ASSESSMENT FILES DATA, GEOSCIENCE RESEARCH OFFICE, TORONTO. SAMPLE NUMBERS CORRESPOND TO LOCATION NUMBERS ON MAP FACE.

Sample	Au	Ag	Cu	Co	Ni	As	Zn	
101	37.03 g/t	trace	1.08%	5.87%	0.12%	10.39%		
102a		5.90 oz/ton	1%					trenching
102b		2.28 oz/ton	33% over					drill data
102c		2.67 oz over 4"	15.76% over 4"					trench 4" x 60' long
103		0.11 oz/ton over 16"						drill data
104				2.96%		trace Ni	0.12% Zn	2' wide-trench
105				0.94%		0.01%	0.02%	trenches
106				0.14%		trace	0.016%	
107a		0.35 oz Ag/ton/10' sludge sample diamond drilling						
107b		0.55 oz Ag/ton/20' sludge sample diamond drilling						
107c		0.55 oz Ag/ton/10' sludge sample diamond drilling						

nomic significance, they are anomalous and further prospecting and sampling in the vicinity for potential PGE mineralization is recommended

Riopel, B., Occurrence [1956] (12)

The Riopel occurrence is located on a peninsula in Cassels Lake within central Cassels Township.

Some minor stripping, trenching and follow-up diamond drilling of six holes for a total of 151 m was carried out for B. Riopel in 1956. The holes are located in the vicinity of the trench, and on either side of a northeast-trending vein/mineralized zone over a length of 100 m. Several minor quartz vein stringers were intersected at a vertical depth of 4 to 6 m. One of these was a 5 cm wide vein with minor chalcopyrite, whereas all others were barren. Lithologies encountered generally consisted of medium- to coarse-grained Nipissing diabase with some very coarse grained varieties. The later type probably corresponds to varied textured Nipissing diabase.

GEOLOGY

The geology of the area consists of the main Nipissing diabase sill sandwiched between pebbly wackes of the Coleman Member which are located some 200 m from either side of the showing. Disseminated 5 percent pyrite mineralization is exposed in the trenches and is hosted by massive, coarse-grained, varied textured Nipissing diabase. Samples taken by the author indicate low values of copper and cobalt with no platinum or paladium.

GROUP 2: OCCURRENCES HOSTED IN PEBBLY WACKES AND CONGLOMERATES OF THE COLEMAN MEMBER ADJACENT TO THE NIPISSING DIABASE SILL

Three occurrences of this type are located in the map area. The major ones are the Silver Leader Mines Limited property (5) and Goldex Mines Limited [1973] (8).

Some geological exploration was also done by Geoscientific Prospectors Limited [1973] (7) and D. Burton [1964] (6) on prospects hosted in similar geological environments.

Silver Leader Mines Limited Property (5)

This property consists of nine contiguous leased mining claims located in central Cassels Township: S58963, S598964, S58971 to S58974 inclusive, S58980, S58999, and S59002.

HISTORY OF EXPLORATION

Silver Leader Mines Limited began a reconnaissance exploration program for silver in 1967 with a stream sediment sampling survey which covered 780 km^2 (300 square miles). Results from the survey lead to the staking of 107 claims and soil sampling over much of central Cassels Township. Sampling was carried out using both compass lines and cut lines and as a result the sample density ranged from one sample per 9120 m^2 (60 by 152 m) to one sample per 900 m^2 (30 by 30 m) in detail areas. Soil sampling was restricted to the B-horizon using a hand auger or grub hoe. Samples were sieved to -80 mesh and analyzed by atomic absorption for Ag, total Co

and total Cu. Threshold values of >27 ppm Cu, >28 ppm Co and >6.3 ppm Ag were established as first order anomalies. As a result, minor silver mineralization was discovered in an area east of Bogie Lake in Cassels Township. A subsequent nine-hole (554 m) drill program carried out in 1968 intersected mainly pebbly wacke and conglomerates of the Gowganda Formation (Coleman Member) and lesser Nipissing diabase and Archean felsic volcanic lithologies. The mineralization consisted of minor disseminated pyrite and galena or minor calcite stringers with 1 to 2 percent chalcopyrite hosted in pebble wackes of the Coleman Member. Adjacent Archean felsic volcanic rocks (rhyolites) contain disseminated pyrite and minor chalcopyrite and sphalerite. Numerous barren calcite stringers also occur in the adjacent Nipissing diabase sill.

Assays from sludge samples range from nil to 0.55 ounce per ton Ag over a width of 3 m (*see* Table 13). Average values are approximately 0.30 to 0.20 ounce per ton Ag over a 3 m section. The presence of minor amounts of sulphide in the holes is probably sufficient to cause the anomalous low silver values.

Following the completion of drilling in 1968, no further work has been done on the property.

GEOLOGY

A thin zone of wackes of the Coleman Member is bounded on the west by Archean felsic volcanic rocks and on the east by Nipissing diabase. No surface mineralization or pits were located by the author in the vicinity of the drill holes which are just east of Bogie Lake. However, the nature of mineralization is known from several previous drill-hole intersections. It consists of minor amounts of pyrite, galena and chalcopyrite either disseminated in sedimentary rocks of the Coleman Member, Archean felsic volcanics and Nipissing diabase or in calcite stringer veins containing these sulphide minerals.

Goldex Mines Limited [1973] (8)

In 1973, Goldex Mines Limited had a property consisting of 30 contiguous unpatented mining claims in the Boulton Lake area of Riddell Township.

HISTORY OF EXPLORATION

The earliest exploration on the property was a three-hole, 107 m diamond-drill program carried out by E. Burke in 1964. The drill holes were located along the eastern shore of Boulton Lake, near some surface sulphide mineralization in Nipissing diabase and adjacent sediments of the Coleman Member.

The drill results showed that only diabase was intersected in hole No.1 with a 10 cm (5 inch) section of hematitized diabase and a 0.3 cm (1/8 inch) calcite stringer with minor galena at a vertical depth of 30 m (100 feet). Lithologies intersected in the second hole (No.3) consisted of both diabase and wackes of the Coleman Member with some minor chlorite, minor pyrite and small quartz vein stringers. The third hole (No.6) which is south of the diabase contact, is in wackes and paraconglomerates of the Coleman Member with a 2.5 cm (1 inch) quartz veinlet containing minor pyrite at a vertical depth of 12 m (40 feet).

Subsequent exploration was resumed in 1972 by Goldex Mines Limited with a program consisting of geological mapping, stripping and trenching, and follow-up diamond drilling consisting of three holes (705 m).

Given below is a summary of the results:

On the east shore of Boulton Lake a prospect pit was excavated at the foot of a cliff, in the face of which is a 30 to 46 cm wide (12 to 18 inch) pyrite- and chalcopyrite-bearing calcite breccia zone with a strike of 081° and a dip of 80°N. Assays indicated only trace silver values. This structure extends eastward on surface and is exposed in a trench and shallow pits for a distance of 60 m (200 feet). The same calcite breccia zone extends 140 m (460 feet) east of the main pit but without significant sulphide mineralization present. The purpose of the first drill hole was to intersect the breccia zone at a vertical depth of approximately 60 m (200 feet) beneath the main pit. Only a 2 cm (3/4 inch) pink calcite veinlet was intersected in the target zone. The second hole was to intersect the same structure at a vertical depth of 100 m (330 feet) but was collared 107 m (350 feet) eastward along strike from the first hole. A 10 cm (4 inch) calcite breccia zone was intersected in the target area. The third hole, located 660 m (2166 feet) northwest of the first hole, was drilled to determine the attitude of the diabase sill and the type of underlying basement rocks. The hole collared in diabase, cut the lower contact of the diabase at 155 m (510 feet) and continued into wackes and conglomerates of the Coleman Member to 264 m (865 feet) where the hole was stopped. No veins were encountered and the hole did not reach Archean basement rocks.

Based on this drill program the breccia structure is only locally well developed at surface near the diabase sill.

No further work was done on the property following the drilling program completed in 1972.

GEOLOGY

The northern half of the Boulton Lake area is underlain by Nipissing diabase and the southern half is underlain by pebbly wackes and matrix-supported conglomerates of the Coleman Member of the Gowganda Formation. Bedding in the sedimentary rocks generally strikes in a northwest direction and dips 15° to 20° to the northeast.

The area in which E. Burke completed several drill holes in 1964 is located north of the diabase-Coleman Member contact in coarse-grained, varied

textured Nipissing quartz diabase. Located 500 m south of the contact is the Goldex occurrence. It consists of an east-trending, 40 cm wide calcite breccia zone (vein?) with minor pyrite and chalcopyrite hosted in pebbly wackes and matrix-supported conglomerates of the Coleman Member. Assays from samples obtained by the author in the 1986 field season are 1.35% Cu, 20 ppb Au and 2 ppm Ag (Sample No. 72 - Table 12, Geoscience Laboratories, OGS, Toronto).

Geoscientific Prospectors Limited [1956] (7)

In 1956, Geoscientific Prospectors Limited held a property which consisted of 18 contiguous, unpatented mining claims along the northwestern shore of Obashkong and Cassels lakes in Cassels Township.

An electrical resistivity survey was carried out on the ice over the lake portions of the property. The results indicated an area of low resistivity approximately 0.4 to 0.8 km (1/4 to 1/2 mile) long.

This anomaly was interpreted as an expression of a shear zone and/or a sulphide-bearing shear zone.

A single 183 m (600 foot) diamond-drill hole was drilled to test the geophysical anomaly. Only wackes and arenites of the Coleman Member were encountered with minor chalcopyrite at a vertical depth of 37 m (120 feet).

Burton, D. [1964] (6)

In 1963, D. Burton staked six contiguous mining claims (T53593 to T53598 inclusive) in central Cassels Township. The property is located west of Obashkong Lake and underlies the area between the Gosselin and the Temagami–Lorraine copper and cobalt occurrences.

Preliminary electromagnetic, geological and soil geochemical surveys were carried out primarily over one claim (T53598) which is located adjacent and east of the Gosselin property (3).

Results from the electromagnetic survey indicated a weak, northeast-trending conductor crosscutting claim T53598. The geological survey identified pillowed and massive Archean andesites, interflow sediments, conglomerates of the Gowganda Formation and a late Keweenawan diabase dike. A subsequent, reconnaissance soil sampling survey was carried out using a McPhar Soil Testing Kit (STK-1). The results which were quoted in zinc equivalent, parts per million (Zn ppm), indicate values of 200 to 300 ppm Zn in areas underlain by Archean volcanic rocks and 150 to 400 ppm Zn in areas underlain by Huronian sedimentary rocks.

GEOLOGY

The claim group is underlain by northeast-trending Archean mafic to intermediate volcanic rocks unconformably overlain by pebbly wackes of the Coleman Member (Gowganda Formation). Nipissing diabase probably occur at depth since an eastward-dipping sill is located just to the west of the claims. Located in the centre of the area is a 200 m wide northwest-striking, late Proterozoic olivine diabase dike.

Only a single exploration pit was located in the 1964 geological survey. The property may have potential for carbonate veins with copper and cobalt mineralization similar to the following nearby showings: the Temagami–Lorraine occurrence (400 m to the northeast), the de Camp showings (400 m to the southwest), and the Gosselin occurrence (800 m to the southwest). As such, their locations define a linear, northeast-trending target zone which transects the western half of the Burton property.

GROUP 3: OCCURRENCES HOSTED IN ARCHEAN VOLCANIC ROCKS (VOLCANOGENIC TYPE MASSIVE SULPHIDE MINERALIZATION)

There are two main properties of this type: the Novamin Resources Inc. property (New Athona occurrence) (2), and the W. Manderstrom property (1) which includes the Brochu, Hermes and Mandy occurrences (Figure 15).

A minor sulphide occurrence of this type is the I. Schubert prospect [1972] (13) in Riddell Township. Numerous geophysical surveys have been completed over unclaimed parcels of land underlain by Archean volcanic rocks in southwestern Cassels Township. These include work done by Lake Beaverhouse Mines Limited [1971] (10); Kevil Mining Group Limited [1965] (9); and Mining Geophysics Company Limited [1956] (11).

Novamin Resources Inc. Property (New Athona Occurrence) (2)

The property consists of five contiguous, unpatented mining claims: S473520 to S473524 inclusive located in southwestern Cassels Township, west of Bogie Lake.

HISTORY OF EXPLORATION

In 1956, the earliest exploration work done on the property was by New Anthona Mines Limited. Twelve trenches and six holes (S-1 to S-6) for a total of 547 m were drilled along a sulphide zone which contains copper and minor zinc mineralization (Figure 14). Drill intersections indicated scattered pyrite, pyrrhotite, chalcopyrite and sphalerite hosted in felsic volcanic rocks. A ground electromagnetic survey was completed in 1962 over the area of the main showings and outlined a 168 by 18 m (550 by 60 feet) wide, northeast-trending conductor. This, however, corresponded to the known sulphide zone which was the site of previous trenching and drilling.

Following the geophysical survey, the claims were allowed to lapse and remained open until 1967

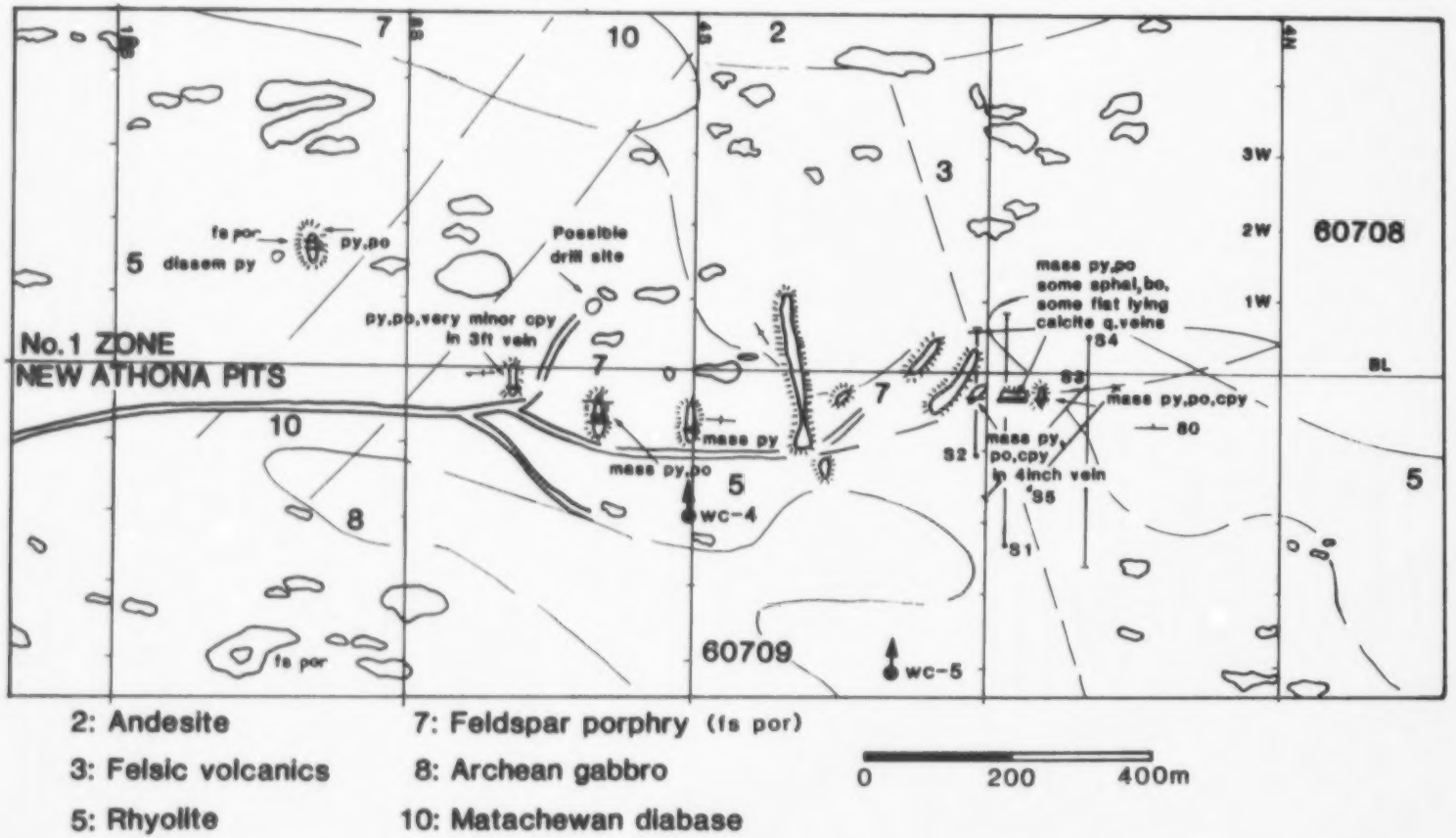

Figure 14. *Geology of the Novamin Resources Inc. Property (New Athona occurrence)(2). Map modified from information found in the Assessment Files Research Office, Ontario Geological Survey, Toronto.*

when the Wabi River Mining Syndicate staked 15 contiguous mining claims in the area. Subsequent electromagnetic and magnetometer surveys and one diamond-drill hole (40 m) were completed in the area in 1968. Results from this hole indicated minor pyrrhotite, pyrite, chalcopyrite and sphalerite mineralization hosted in felsic volcanic rocks.

Rio Tinto Canadian Exploration Limited optioned the property from the Wabi River Mining Syndicate in September 1969. Subsequent geological and geophysical surveys were completed in 1969. A follow-up diamond-drill program of four holes (506 m) was carried out in 1970.

Geophysical magnetometer and electromagnetic surveys were carried out using a 122 m (400 foot) spacing between lines. Six conductive zones (A to F), were encountered. Zones A, B and C are located on a rhyolite-diabase contact and anomalies D, E and F are in andesites. Detailed geological mapping was carried out using the same 122 m (400 foot) grid. A detailed description of the mineralized zones is given in the assessment report by C. Sampson.

A short summary of his conclusions is given below:

> The New Athona occurrence consists of 16 major trenches situated between 2+00N on the baseline and 6+00N at 18+00S (*see* Figure 14). Six holes by New Athona Mines Limited were drilled beneath the zone. Mineralization generally consists of veins containing massive pyrite, pyrrhotite and chalcopyrite up to 2 m (6 feet) wide which mainly trend northeast and dip vertically. A minor shear zone (1 m wide) is exposed along the eastern wall of the pits. Otherwise the mineralized rocks are not very sheared but are bleached and silicified. This is indicative of metasomatic, hydrothermal alteration. Some grab samples of heavily mineralized rock gave values of 2.06% Cu, 0.12% Zn and trace Ni, 0.94% Cu, 0.02% Zn and 0.01% Ni.

The amount of sulphides intersected in drill holes S-1 to S-6 is considerably diminished from that found in overlying trenches at surface. Therefore, the mineralization appears to decrease with depth.

The Rio Tinto drill program consisted of five holes to test the four electromagnetic anomalies which are all located in areas of minor outcrop.

One of the four holes (WC-1) was drilled on the adjacent Manderstrom property (1) (see later description). Results from the four-hole drill program showed sufficient mineralization to explain the conductors but only low Cu, Zn, Ag and Ni values were detected. Mineralization of disseminated pyrite+ pyrrhotite and trace chalcopyrite occurs as fracture filling and stringer sulphides in altered rhyolite.

Pyrite is principally encountered in veins in the rhyolite. In the feldspar porphyritic diabase, pyrrhotite±pyrite and chalcopyrite are the principal sulphides.

Sulphide mineralization is attributed to the intrusion of the diabase adjacent to the rhyolites and the low assay values indicates the absence of copper and zinc.

The conclusion of the drill program ended an active exploration period from 1955–1970 in which 1093 m of diamond drilling in 10 holes was completed and 12 trenches were blasted on the property.

The claims were allowed to lapse and five claims were restaked by St. Joseph Exploration Limited in June 1977. An electromagnetic survey completed in 1978 was the last exploration work done on the property. No further data is available on the results of this survey.

Novamin Resources Inc. acquired ownership of the claims following the purchase of all mineral assets of Sulpetro Minerals Limited which had previously purchased St. Joseph Exploration Limited.

GEOLOGY

The property straddles the contact between Archean volcanic rocks and an altered gabbro-diabase body. Northeast-trending Archean rhyodacites and felsic pyroclastic rocks are intercalated with basaltic to andesitic pillowed lavas in the northern part of the property. Alteration and deformation suggest that the gabbro is Archean rather than Proterozoic (Nipissing) in age. Furthermore, mapping and drilling by Rio Tinto Canadian Exploration Limited (1969) indicate that the gabbro is cut by Archean Matachewan diabase dikes.

The rhyolite-diabase contact appears to be the main pathway for hydrothermal fluids and associated sulphides. Volcanogenic massive sulphide mineralization consisting of pyrite, pyrrhotite and minor chalcopyrite and sphalerite typically occur as sulphide veins in hydrothermally altered, felsic volcanic flows and/or pyroclastic rocks. They possibly represent stringer zones associated with sulphide deposits.

Samples taken during the 1986 field season (Sample Nos. 16 to 18 and 25 - Table 12) indicate low gold and silver values with 188 to 650 ppm Cu and 38 to 420 ppm Co (Geoscience Laboratories, OGS, Toronto).

Manderstrom, W., Property (includes the Brochu, Hermes and Mandy Occurrences) (1)

This property is located in the Boot Bay area (Net Lake) of southwestern Cassels Township and consists of 15 contiguous unpatented mining claims: S494564 to S495578 inclusive.

HISTORY OF EXPLORATION

The staking of several mineral claims (J.S. 10, J.S. 11, and J.S. 108) in the Boot Bay area prior to 1925 (Todd 1925) represents the earliest known mineral exploration activity in the area of the Manderstrom property. However, there is no data on what type of work was done on these early claims.

The earliest recorded exploration work was done by Hermes Mines Limited in 1945. It consisted of electromagnetic surveys and subsequent blasting of 25 trenches and drilling of 10 holes for a total of 801 m. All of the trenching occurred at three sulphide showings currently known as the Brochu, Hermes and Mandy occurrences (GD1F 117-Cassels Townships) (*see* Figure 15).

One hole was drilled beneath the Hermes showing but no mineralization was intersected. The remaining nine holes were drilled to check electromagnetic conductors and local sulphide mineralization at three locations (*see* Figure 15) along the western shore of Outlet Bay (Net Lake). Results from the drilling indicated scattered and disseminated pyrite, pyrrhotite and minor chalcopyrite and sphalerite mineralization in all holes. Iron formation was also encountered in two of the holes.

Subsequent work was done on the Brochu showing by A. Brochu, in 1955. It consisted of 178 m of diamond drilling (five holes) around the showing. The results indicated disseminated (up to 10 percent) pyrite, pyrrhotite with minor chalcopyrite, sphalerite and galena mineralization hosted in sheared and altered felsic volcanic rocks. Minor quartz, quartz-carbonate and carbonate veins were also intersected. A total of 11 trenches are located near the Brochu showing. Some of these were blasted by Brochu while others were previously excavated by Hermes Mines Limited in 1945.

In 1956, work by New Athona Mines along the eastern edge of the present property consisted of minor trenching (2 trenches) and diamond drilling of five holes (H-1 to H-5) for a total of 445 m. The trenches exposed some pyrite with minor pyrrhotite and chalcopyrite in several 2 to 30 cm wide quartz veins. The veins are perpendicular to the diabase-dacite contact and are hosted in both lithologies. Disseminated sulphides also occur in the dacite.

Generally, all of the sulphide mineralization in the area is minor and probably related to the intrusion of the diabase. Results from the drill hole indicated similar mineralization to that located in the trenches. Minor pyrrhotite, pyrite and chalcopyrite were intersected in each of the five holes.

Trenching was also carried out by New Athona Mines Limited on an occurrence referred to as the Riopel showing which probably corresponds to the Mandy occurrence (*see* Figure 15). It consists of a northeast-trending, vertical band of massive pyrite up to 60 cm thick hosted in altered andesites and rhyolites. No chalcopyrite or sphalerite apparently occurs with the massive pyrite and thus, no diamond drilling was done in the vicinity of the showing.

In 1956, self-potential and resistivity surveys in the Boot Bay area were carried out by Westville Mines Limited and the Temagami Mining Company. Results from the self-potential survey indicated four anomalies which were interpreted to represent sulphide mineralization in a northeast-trending shear zone across Boot Bay (*see* Figure 15). The resistivity survey covered the northern part of the property and also outlined a few areas of low resistivity.

Following these surveys, there was a period of inactivity until 1969 when exploration interests were renewed by Rio Tinto Canadian Exploration Limited at the adjacent, New Athona occurrence. Some of this work covered the northern part of the Manderstrom property. As a result, geological and geophysical surveys and one drill hole (WC-1 for 90 m) were completed within the boundaries of the present Manderstrom property. A northeast-trending conductor was outlined adjacent to the northeast shore of Outlet Bay. Hole WC-1 was drilled to intersect the conductive zone and to investigate possible sulphide mineralization. Results indicated narrow stringer veins of pyrite, pyrrhotite and minor chalcopyrite hosted in pillowed andesites with only trace values of Au, Ag, Cu, Zn and Ni. The lithologies encountered are similar to the nearby Riopel showing (Mandy occurrence).

No further exploration was done until 1970 when Lake Beaverhouse Mines Limited (10) carried out an EM-VLF survey which covered the southwestern part of the property. Results from the survey indicated a major 2500 m, northeast-trending conductor intersected by a north-trending conductor east of Boot Bay. These conductors lie in the Link Lake deformation zone which is a carbonatized and sericitized zone associated with mineralized graphitic zones. No further work was done and the claims were allowed to lapse.

Several years later, the Canadian Nickel Company Limited staked 45 contiguous, unpatented mining claims in southeastern Strathy and southwestern Cassels townships including the area of the Manderstrom property. Linecutting and geophysical and geological surveys followed in 1974. No data however, is available for the geophysical survey. A detailed geological survey (1:2400 scale) was done using a grid with lines every 122 m (400 feet). Results from the mapping concluded that the property represented a favourable environment for volcanogenic copper-zinc sulphide mineralization. A series of northeast-trending Archean felsic pyroclastic and flow units intercalated with andesite and basalt were identified. The following stratigraphic succession was established with the oldest units (unit 1) occurring in the north and the youngest (unit 11) in the south:

1. Andesite - (minimum 500 m thick)
2. Rhyolite flows (250 m thick) - chloritic in places
3. Lapilli tuff-tuff breccia (250 m thick) - rhyodacite composition. The unit contains minor chalcopyrite and sphalerite with pyrite at several locations.
4. Rhyodacite flows (127 m thick) - Flows are variably chloritic, sericitic and carbonatized with

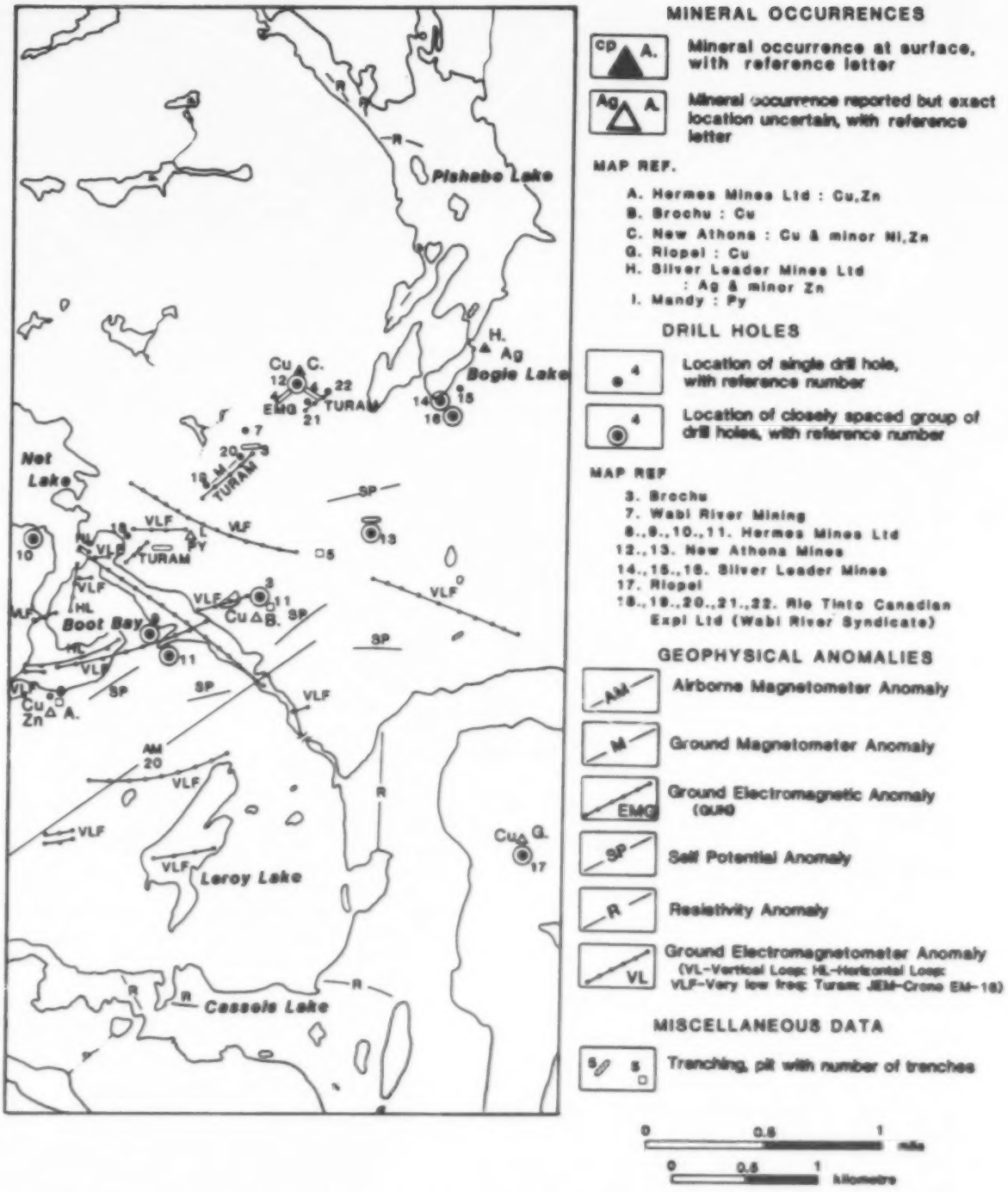
MINERAL OCCURRENCES
Mineral occurrence at surface, with reference letter
Mineral occurrence reported but exact location uncertain, with reference letter
MAP REF.
A. Hermes Mines Ltd : Cu,Zn
B. Brochu : Cu
C. New Athona : Cu & minor Ni,Zn
G. Riopel : Cu
H. Silver Leader Mines Ltd : Ag & minor Zn
I. Mandy : Py
DRILL HOLES
Location of single drill hole, with reference number
Location of closely spaced group of drill holes, with reference number
MAP REF
3. Brochu
7. Wabi River Mining
8.,9.,10.,11. Hermes Mines Ltd
12.,13. New Athona Mines
14.,15.,16. Silver Leader Mines
17. Riopel
18.,19.,20.,21.,22. Rio Tinto Canadian Expl Ltd (Wabi River Syndicate)
GEOPHYSICAL ANOMALIES
Airborne Magnetometer Anomaly
Ground Magnetometer Anomaly
Ground Electromagnetic Anomaly (GUPO
Self Potential Anomaly
Resistivity Anomaly
Ground Electromagnetometer Anomaly
(VL-Vertical Loop; HL-Horizontal Loop; VLF-Very low freq; Turam; JEM-Crone EM-16)
MISCELLANEOUS DATA
Trenching, pit with number of trenches
Pishabo Lake
Bogie Lake
Net Lake
Boot Bay
Leroy Lake
Cassels Lake
TURAM
VLF
SP
EMG
0 0.5 1 miles
0 0.5 1 kilometre

Figure 15. *Location of geophysical conductors, drill holes, exploration shafts, pits and mineral occurrences in western Cassels Township. Map modified from GDIF 117-Cassels Township.*

some isolated pyrite and pyrrhotite mineralization.

5. Andesite (100 m thick)
6. Quartz-feldspar crystal tuff (150 m thick) intensely sheared in an easterly direction
7. Andesite (200 m thick) - intensely sheared in an easterly direction
8. Rhyodacite - agglomerate to tuff lithologies (305 m thick) with some minor sulphides
9. Andesite (103 m thick)
10. Rhyodacite agglomerate to tuff lithologies (127 m thick)
11. Basalts (minimum 560 m thick) - contains some disseminated pyrite and pyrrhotite

The andesite units (1, 5, 7 and 9) are massive to pillowed flows with some minor pyrite, pyrrhotite and chalcopyrite along several shear and joint planes.

Pyroclastic fragment size variations in units 8 and 10 indicate that the source of the volcanism lies near Outlet Bay or further to the east.

Geological mapping and a subsequent structural interpretation by the company identified a fault along the northeast shore of Outlet Bay and a major shear zone beneath Johnny Creek and Boot Bay (Link Lake deformation zone).

The report also states that the best mineralization occurs at several localities along the contact between units 2 and 3 where an old pit (probably by Hermes Mines Limited 1945) exposes weakly to heavily disseminated pyrite with pyrrhotite, chalcopyrite and sphalerite mineralization. The zone is 60 cm wide and several metres long. Another old pit (by Hermes Mines Limited, 1945) in the eastern part of the property (east of Outlet Bay and the hydro line) exposes heavily disseminated pyrite along a shear zone. Several other pits were located by the survey but none contained any significant mineralization.

No further work was done on the property until the claims were restaked by W. Manderstrom in 1977 and optioned to Hollinger Mines Limited. Subsequent linecutting and electromagnetic surveys were completed in 1978. On the western part of the property, a survey was completed with a horizontal loop electromagnetic unit, while elsewhere due to more rugged terrain and hydro lines, a VLF-EM receiver was used. Results from the surveys indicated two bedrock anomalies which had been previously discovered by trenching. No further exploration work has been done since 1978. The property was subsequently transferred back to the original vendor, W. Manderstrom, in August 1986.

GEOLOGY

The geology of the property consists mainly of felsic pyroclastic tuff, lapilli tuff, lapillistone and minor tuff breccia intercalated with less abundant mafic volcanic flows. Detailed mapping by the Canadian Nickel Company Limited in 1974 (see above) illustrated the complexity and variability of the volcanic stratigraphy. Mapping by the author during the 1986 field season outlined several intercalated mafic to intermediate units but not nearly as many as in the previously discussed 1974 detailed mapping.

This apparent discrepancy can be attributed to the greater detail at which the 1974 mapping was done. These volcanic rocks represent the northeast extension of the Temagami greenstone belt and are on the northern limb of the Lake Tetapaga syncline. A major northeast-trending deformational zone (the LLDZ) cuts across Boot Bay and continues eastward. This is an area of high strain with extreme flattening, shearing and associated carbonatization, sericitization and variable silicification.

A total of 27 trenches and 21 drill holes (1524 m) have been completed in areas of known sulphide mineralization. At least three main and several lesser sulphide occurrences are located on the property. The three main occurrences are named the Brochu, Hermes and Mandy occurrences. Of the three showings, only the Brochu occurrence (*see* Figure 15) was not located in spite of several attempts by the author in 1986. However, the Brochu showing is well described in an assessment work report by Rio Tinto Canadian Exploration Limited in 1970:

> A 2-3 foot (60-100 cm) wide fault zone which is well sheared strikes at N 50°E and dips at 45° to 70° to the south. The zone contains some pyrite and very minor chalcopyrite mineralization.

Drilling by Brochu in 1955 near the showing indicated disseminated (up to 10 percent) pyrite, pyrrhotite with minor chalcopyrite, sphalerite and galena hosted in sheared and altered felsic volcanics.

The Mandy occurrence consists of a northeast-trending, 60 cm wide band (bed?) of massive pyrite hosted by sheared and altered dacite and/or andesite. Nearby drilling (hole WC-1) by Rio Tinto Canadian Exploration Limited indicated stringers of pyrite, pyrrhotite and minor chalcopyrite hosted in altered andesites.

A pit near the reported location of the Hermes occurrence was examined by the author and contained a 10 cm wide quartz vein with minor pyrite hosted in sheared and altered andesites. Drilling in this area by Hermes Mines Limited in 1945 did not outline any sulphide mineralization.

Another area of sulphide mineralization in the northern part of the property was located by the Canadian Nickel Company Limited in 1974. Pyrite, pyrrhotite, chalcopyrite and sphalerite occur along a contact between a rhyolite and overlying tuff breccia

unit. Previous pits and drilling of four holes in the vicinity by Hermes Mines Limited (1945) outlined minor pyrite, pyrrhotite, chalcopyrite and sphalerite mineralization.

Several extensive geophysical surveys were completed over the property. Numerous conductors were outlined (*see* Figure 15) but only a few conductors were drilled by several shallow and widely spaced holes.

Thus, there is still potential for locating additional volcanogenic sulphide mineralization within this favourable geological environment.

Schubert, I., Occurrence [1972] (13)

In 1970, I. Schubert staked twelve contiguous unpatented mining claims in the southeastern part of Strathcona Township and the southwestern part of Riddell Township. The property is located west of Lower Twin Lake and consisted of claims T213417 to T213508 inclusive. Six of the claims are in Riddell Township while six are west of the map area in Strathcona Township.

Exploration work consisting of geological and geophysical surveys, trenching and stripping were carried out from 1970 to 1972. VLF-EM and magnetometer surveys outlined three weakly anomalous areas. A subsequent interpretation of the geophysical data indicated that one of the anomalies was due to overburden, while the other two were caused by minor pyrite mineralization exposed in previously blasted trenches.

A geological sketch map showed three trenches hosted by agglomerates and basalts with several porphyry, granite and lamprophyre dikes in the vicinity. Shear zones occur in all three trenches with pyrite and minor chalcopyrite, pyrrhotite, galena, bornite and sphalerite mineralization.

In 1974, subsequent trenching by G. Valliancourt was done in the area of sulphide mineralization. No other data concerning this work is, however, available.

GEOLOGY

The property is underlain by mafic volcanics consisting of massive flows, pillowed flows and pillow breccias of the older volcanic complex (Fyon and Crockett 1986). Mineralization consisting of minor disseminated pyrite is hosted in fractures within a mafic to intermediate (andesite) pillow breccia or flow breccia unit. The presence of minor chalcopyrite and sphalerite as previously reported was not confirmed by a field examination in 1986 by the author.

Lake Beaverhouse Mines Limited [1971] (10)

In 1971, Lake Beaverhouse Mines Limited held a property consisting of 50 unpatented, contiguous mining claims in Strathy and Cassels Township. Thirty-seven of these claim numbers, T267020 to T267031 inclusive and T266982 to T267006 inclusive, were in the map area in Cassels Township west of Cassels Lake. Much of the northern part of the survey area covered the Manderstrom property (1). The results have been described and discussed under a previous heading for property (1).

The work consisted of a detailed VLF-EM survey using an east-west baseline and north-south picket lines every 120 m (400 ft). Two transmitting stations were used in the survey: Seattle, Washington to search for east-trending conductors and Balboa, Panama for north-trending conductors. Several conductors were outlined by the survey. One of these, as previously mentioned, is an east-trending conductor (2500 m long) along Link Creek through Boot Bay (*see* Figure 15). The strongest part of the conductor underlies Boot Bay. Several weaker and smaller conductors are parallel to this major conductor. In the eastern part of the property, a 1000 m long, east-trending conductor cuts across the northern tip of Leroy Lake. A shorter (400 m) east-trending conductor is located beneath Leroy Lake and may be due in part to overburden effects.

GEOLOGY

Underlying the area are Archean felsic and mafic volcanics in the north and sedimentary rocks of the Gowganda Formation (Coleman Member) in the south. Numerous sulphide occurrences are hosted in the volcanic rocks.

The northeast-trending, major conductor corresponds to the LLDZ whereas the conductor north of Leroy Lake appears to correspond to the unconformable geological contact between Archean metavolcanics and overlying Huronian sedimentary rocks.

Keevil Mining Group Limited [1965] (9)

In 1965, the Keevil Mining Group Limited held 70 contiguous unpatented mining claims known as the O'Connor and Temagami Townsite groups located in Strathcona, Strathy and Cassels townships.

Combined airborne electromagnetic and magnetometer surveys were flown at a height of 23 m (75 feet) above ground level. Flight lines were approximately 200 m (1/8 mile) apart in a N25°W direction. Approximately the western half of Cassels Township was included in the survey. Results indicated no electromagnetic anomalies. Several magnetic anomalies were outlined but most were satisfactorily explained by known geological features. One east-trending anomaly which is located west of Snake Island Lake corresponds to an olivine diabase dike. A linear, east-trending, magnetic high anomaly which is located north of Leroy Lake probably corresponds to a zone of basalts.

GEOLOGY

The part of the survey which covered western Cassels Township is underlain by Archean volcanic rocks of the Lake Tetapaga syncline in the north

and by younger and overlying sedimentary rocks of the Coleman Member (Gowganda Formation) in the south. The long, linear, east trending magnetic high anomaly near Outlet Bay corresponds to basaltic rocks.

Mining Geophysics Company Limited [1956] (11)

Mining Geophysics Company Limited formerly held two properties in Cassels Township during 1956. One of these consisted of 23 contiguous, unpatented mining claims covering much of Cassels Lake from Snake Island Lake to Outlet Creek. The other property consisted of eight contiguous, unpatented mining claims covering all of Pishabo Lake. Electrical resistivity surveys were carried out from the ice and located three east- and north-trending resistivity (low) anomalies on Pishabo Lake (*see* Figure 15). Most of the resistivity low areas have been previously interpreted as the expression of east-, north- and northwest-trending faults.

GEOLOGY

Both areas are predominantly underlain by sedimentary rocks of the Gowganda Formation (Coleman Member) which consist of pebbly wackes and minor siltstones, arkoses and matrix-supported conglomerates. A Nipissing diabase sill intrudes the Coleman Member sediments along the eastern edge of the claim group on Cassels Lake. One of the areas of low resistivity parallels this contact. The others are east trending and probably represent east-trending faults.

On the Pishabo Lake property an east-trending resistivity anomaly corresponds to the unconformable contact of the Coleman Member with Archean basement rocks. The other two northwest-striking resistivity anomalies correspond to the geological contacts between Middle Proterozoic olivine diabase dikes and pebbly wackes of the Coleman Member. Alternatively some northwest-trending faults may parallel the diabase contact and thus, represent the probable expression of the low resistivity anomaly. None of the resistivity anomalies were subsequently checked by diamond drilling. Also, there is no apparent relationship between the resistivity lows and any known local metal occurrences.

RECOMMENDATIONS FOR FUTURE MINERAL EXPLORATION

Three areas with potential for veins with cobalt, silver and copper mineralization are: a) along the upper margin of the Nipissing diabase sill; b) in sedimentary rocks of the lower part of the Coleman Member adjacent to the lower diabase contact; or c) in sediments of the lower Coleman Member which overlie Archean sulphide-bearing felsic or mafic metavolcanic rocks but are stratigraphically below the lower diabase contact (Figure 16). Geological environments as mentioned above are analogous to the Cobalt Camp (Legun 1986; Andrews et al. 1986), and the presence or absence of mineralized veins is controlled by locally developed structures and difficult to predict. Most of the known local veins are vertical and trend in a northeast direction, and are hosted by a varied textured diabase. Previous prospecting and near-surface drilling discovered numerous indications of mineralized veins. Higher-grade veins may be present at depth along any of the key stratigraphic horizons previously discussed.

Disseminated sulphides in the diabase are minor, but of interest for potential PGE mineralization. Several studies of the PGE potential of Nipissing diabase rocks in other areas have been completed over the past few years (Conrod and Naldrett 1985; Rowell and Edgar 1984; Lightfoot et al. 1986). Sampling by the author in the Cassels and Riddell area, however, has not yet yielded any significant results

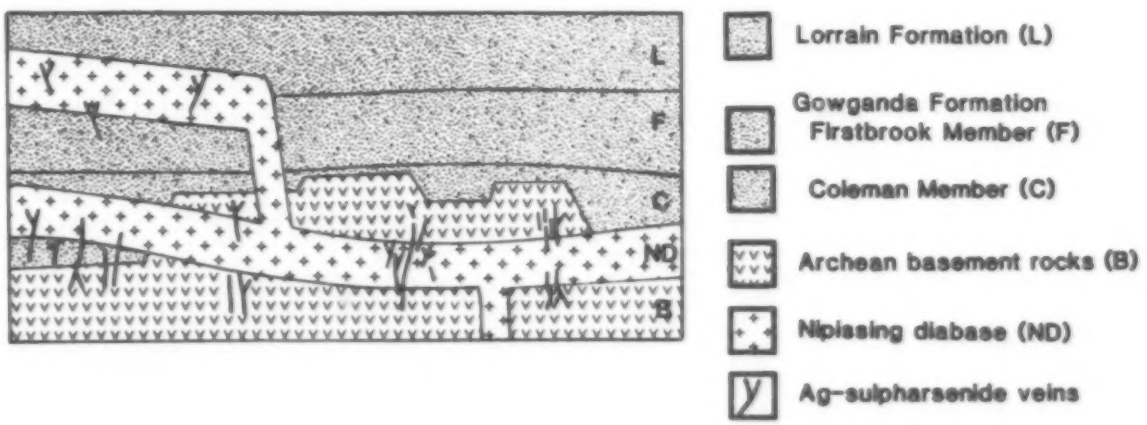

Figure 16. *Simplified geological section showing the relationship between major lithologic units and the distribution of Ag-sulpharsenide vein systems (black lines). Diagram taken from Andrews et al. (1986).*

with the highest values of 50 ppb Pt and 30 ppb Pd from a calcite vein with smaltite hosted by Nipissing diabase at the Upper Twin Lake occurrence (14) in Riddell Township (*see* previous description). Further prospecting of this area may yield additional and more positive indications of PGE mineralization.

The area underlain by Archean metavolcanic rocks has been previously covered by various electromagnetic surveys and most major conductors have been drilled, all with negative results for economic base metal mineralization. Thus, although the geological environment for massive sulphide deposits is good, the best potential that remains is for deeper diamond drilling and subsequent down-hole geophysical surveys to establish the possible presence of a deeply buried orebody.

The geological environment is generally favourable for gold mineralization within the Archean metavolcanic rocks in Cassels Township. These are part of the younger volcanic complex of the Temagami greenstone belt. Although no major gold occurrences have been reported in the map area, arsenopyrite-rich gold mineralization does occur in north-trending, chloritized shear zones hosted in mafic metavolcanics at the Big Dan showing (Fyon and Crockett 1986; Bennett 1978) some 2 km to the west of the map area in Strathy Township. Therefore, by analogy, north-trending, chloritized shear zones within volcanic rocks in the Boot Bay area may represent good targets for gold exploration. Many of the southeast-trending conductive zones outlined by previous electromagnetic surveys could represent such zones.

Previous structural studies in Archean greenstone terranes illustrated that major gold deposits occur in regional zones of deformation (Fyon and Crocket 1986; Hugon and Schwerdtner 1985). Thus, the LLDZ may be an area for potential gold mineralization. Some intensely carbonatized and/or silicified zones are associated with this northeast-trending zone which cuts across Boot Bay. Other geological features, such as the presence of felsic pyroclastic rock units with some minor sulphide mineralization, and areas of minor quartz veining and intense shearing and flattening of metavolcanics, make the LLDZ a good target for gold exploration.

High gold values (from 1 to 38 g/tonne) are associated with copper- and cobalt-bearing quartz-carbonate veins hosted in varied textured Nipissing diabase near the margins of the sill (properties 3 and 4). The gold values may be due to tellurides associated with some of the arsenic-bearing sulphides. Further investigation of similar occurrences may yield some additional gold exploration targets.

PROPERTIES, MINERAL DEPOSITS

Properties:

1. Manderstrom, W., Property (includes Brochu, Hermes and Mandy occurrences)
2. Novamin Resources Inc. Property (New Athona occurrence)
3. Plexman, E., Property (Gosselin occurrence)
4. Quebec Cobalt and Exploration Limited Property (Temagami–Lorraine occurrence)
5. Silver Leader Mines Limited Property

Unclaimed Parcels of Explored Land:

6. Burton, D. [1956]
7. Geoscientific Prospectors Limited [1956]
8. Goldex Mines Limited [1973]
9. Keevil Mining Group Limited [1965]
10. Lake Beaverhouse Mines Limited [1971]
11. Mining Geophysics Company Limited [1956]
12. Riopel, B., Occurrence [1956]
13. Schubert, I., Occurrence [1972]
14. Upper Twin Lake Occurrence

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